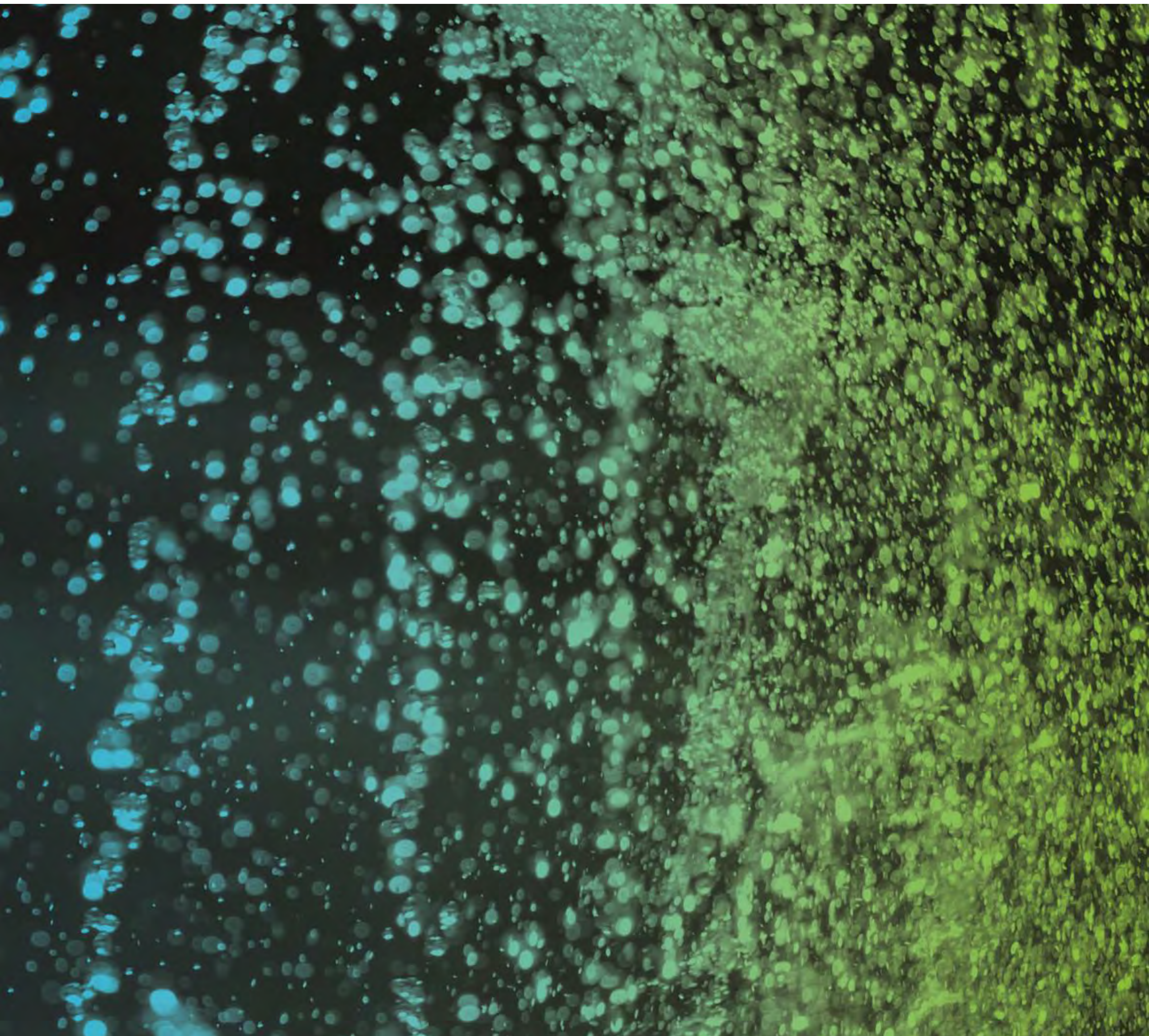
Appendix M

Underwater Noise Impact Assessment

Liberty Natural Gas, LLC
28-August-2014

Underwater Noise Impact Assessment

Port Ambrose Deepwater Port License Application



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Glossary

Ambient sound	Background environmental noise not of direct interest during a measurement or observation.
dB	Decibel, unit used in the logarithmic measure of sound strength.
dB_{peak}	Peak sound pressure over the measurement period, expressed in dB re 1 μPa.
dB_{rms}	Root mean square sound pressure over the measurement period, expressed in dB re 1 μPa.
Hz	Hertz. The number of cycles per second and refers to the frequency of the particular noise.
M-weighting	Frequency weightings designed to best reflect the hearing sensitivity of marine mammals, similar to the use of the A-weighting for measuring noise impacts on humans. Noise levels for low frequency cetaceans are expressed in decibels using the Low Frequency M-weighting function, annotated as $dB(M_{lf})$.
Pa	Pascal, the international standard unit of sound pressure.
PTS	Permanent Threshold Shift. Irreversible and permanent reduction in auditory sensitivity.
SEL	Sound Exposure Level. Sound energy over the measurement period expressed in dB re 1 μPa^2s. SEL is commonly used for impulsive underwater noise sources such as impact pile driving because it allows a comparison of the energy contained in impulsive signals of different duration and peak levels. The measurement period for impulsive signals is usually defined as the time period containing 90% of the sound energy.
SPL	Sound Pressure Level. The sound pressure averaged over the measurement period, expressed in dB re 1 micro Pascal (μPa). Continuous noise sources such as vibro-piling and dredging are commonly characterized in terms of an SPL.
SL	Source Level. The intensity of underwater noise sources is compared by their source level, expressed in dB re 1 μPa for SPLs and dB re 1 μPa2s for SELs. The source level is defined as the sound pressure (or energy) level that would be measured at 1 meter from an ideal point source radiating the same amount of sound as the actual source being measured.
TTS	Temporary Threshold Shift. Short-term reversible reduction in auditory sensitivity. TTS will be gradually reversed upon removing exposure to the high noise levels that cause the change in hearing sensitivity.

Executive Summary

This report presents an assessment of impacts from underwater noise associated with construction, operations, routine maintenance, decommissioning and unplanned events from the proposed Port Ambrose Deepwater Port to be located in the New York Bight. The purpose of this assessment is to determine if a species listed under the Endangered Species Act (ESA) as endangered or threatened, or marine mammals protected under the Marine Mammal Protection Act (MMPA) could potentially be impacted by underwater sound generated by the proposed Project.

Liberty Natural Gas, LLC (Liberty) is proposing to construct, own, and operate a deepwater port, known as Port Ambrose (Port Ambrose, or the Project) in the New York Bight. In-water construction of the Project is scheduled to be completed during a 10 month period in 2016, with the first delivery of natural gas planned for December.

Underwater sounds will be generated during the construction, operations, routine maintenance and decommissioning phases of the Project. Offshore sound could also be generated in the event of an unplanned incident. Offshore construction of the Project will involve the installation of two Submerged Turret Loading buoy (STL buoy) systems and two offshore subsea lateral pipelines (Laterals) that will be connected to a subsea natural gas mainline (Mainline) which will connect to an existing gas pipeline.

Potential sources of underwater sound during the construction phase include sounds from suction piling (or impact piling, if deemed necessary), pipeline installation, interconnection and lowering/backfilling. Although underwater sound measurements of suction pile installations are not available, it is expected that the noise from this method of anchor placement would be negligible relative to other construction methods because the only noise source is the suction pump (Spence et al. 2007). All impulsive sounds are removed using this approach (CSA Ocean Sciences Inc. 2014). In the unlikely event that the alternative method of impact piling is needed, it is anticipated to be a much higher energy source of underwater sound during the construction phase of the Project.

Operation of the Port will consist of LNG regasification vessels (LNGRVs) approaching and mooring at the Port, before regasifying LNG to deliver natural gas over an anticipated period of 5-16 days per shipment. The highest-energy source of underwater sound during the operation phase will be from vessel transits near the Port and from mooring activities. The Project is to be constructed approximately 30 miles offshore of the Port of New York and New Jersey, which is considered the third busiest port in the United States. Vessel sounds during operations will result from propeller cavitations and propulsion, in addition to flow noise from water dragging across the hull and bubbles breaking in the wake. The dominant sound source from vessels is propeller cavitations with noise intensity dependent upon size and speed of the vessel. Noise impacts from LNGRVs are expected to be comparable to those generated by common and existing vessel traffic in the New York Bight. Underwater sound generated from routine maintenance, decommissioning and unplanned events will be similar, but shorter in duration, to those of the construction and operation phases of the Project.

Several species listed as endangered or threatened under the ESA and/or protected under the MMPA could occur in the vicinity of the Project, as identified by the U.S. Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) in letters to Liberty and the United States Coast Guard (USCG), and the United States Department of Transportation Maritime Administration (MARAD).

Underwater sound source modelling for the construction and operation of the Project has been undertaken by JASCO Applied Sciences, and results are detailed in their report Port Ambrose Deepwater LNG Terminal – NOAA Criteria Edition (2014). We have summarized the results of that report as relevant to our noise assessment. Sound levels have been assessed against criteria derived from U.S. policy and recent guidance concerning marine fauna hearing. For example, NOAA's Draft Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammals (2014) is used for assessing the potential impacts of underwater sound sources on marine mammals.

For this impact assessment, risks to marine species potentially impacted by exposure to anthropogenic sound sources from the Project were assessed and ranked using objective criteria. NOAA (2014) suggests that qualitative factors such as exposure duration and frequency of exposure be considered when undertaking an impact assessment, in addition to comparison of predicted levels with objective noise criteria. We have included such factors in our assessment.

Because impact piling was assessed to have the highest potential for sound generation associated with the proposed Project, a technical feasibility study was conducted to determine if suction pilling is a possible alternative to impact piling (Moffatt and Nichol 2014). According to the Design and Installation Concept Verification study done by Moffatt and Nichol (2014), it is expected that the anchors can be installed in the sandy ground conditions and water depths anticipated at the Port Ambrose deepwater port site using suction piles.

Because suction piles will be used during the construction phase of the Project, a low level of risk has been identified for cetaceans, sea turtles, and fishes from sound generated by pile placement. Operational, routine maintenance and decommissioning activities are also expected to have a low level of risk to protected marine fauna because vessel noise is expected to be comparable to that generated by common and existing vessel traffic in the surrounding area and because animals have the ability to move away from potential sound sources.

In addition to suction piling, additional mitigation strategies have been identified which will be adopted as part of a reasonable and prudent approach to further minimize risk to protected species. With an appropriate combination of these mitigation strategies in place, the risk of sound sources causing harassment or harm to marine mammals, sea turtles, and fish species is further reduced.

1.0 Introduction

1.1 Objectives of the noise assessment

Liberty is proposing to construct, own, and operate the Port Ambrose deepwater port in the New York Bight. The purpose of this Noise Assessment is to determine if a species listed under the ESA as endangered or threatened, or marine mammals protected under the MMPA could potentially be impacted by sounds produced from the proposed Project.

This assessment will include a description of the proposed Project and any underwater noise sources generated by Project activities; current information on the abundance and distribution of protected marine species in the vicinity of the Project; an analysis of the potential direct and indirect effects of underwater sound from the proposed Project; and identification of proposed measures to avoid, minimize, and mitigate anticipated impacts related to underwater sound from the proposed Project.

The objectives of this assessment are to describe how the actions proposed by the Project may affect ESA or MMPA listed marine mammals, turtles and fish, as designated by NOAA's National Marine Fisheries Service (NOAA Fisheries) Office of Protected Resources (OPR) and United States Fish and Wildlife Service (USFWS) who, in conjunction with the USCG, and MARAD, will evaluate the potential impact of this Project on protected marine species and their critical habitat. This document is intended to provide information and support to the above agencies in order to consult with NOAA Fisheries OPR for the issuance of a Biological Opinion (BO) that will assess the proposed impacts of the Project and its potential to impact protected marine species as part of the NEPA process and ESA Section 7 Consultation Process.

1.2 Project overview

Port Ambrose is similar in design to two offshore Liquefied Natural Gas (LNG) ports near Boston, Massachusetts and an approved port near Tampa, Florida. The Project consists of two basic sets of components: two STL Buoy systems and an offshore pipeline system. The STL Buoy systems (collectively, the Port) will receive and transfer natural gas from purpose-built LNGRVs to the pipeline system (Figure 1-1). Two offshore Laterals will be connected to a subsea natural gas Mainline (collectively, the Mainline) which in turn will interconnect to an existing gas pipeline owned by the Transcontinental Gas Pipe Line Company (Transco) for eventual transfer to shore.

The STL Buoy systems will be located in water depths of approximately 103 ft (31 m), in federal waters; approximately 16 nautical miles (30 km) off Jones Beach, New York; approximately 25 nautical miles (45 km) east of Long Branch, New Jersey; and approximately 27 nautical miles (50 km) from the entrance to New York Harbor (Figure 1-2). Natural gas will be delivered from LNGRVs through the STL Buoy systems and Laterals into a buried, 19 nautical mile (35 km) subsea Mainline, which will connect offshore with the existing Transco pipeline for delivery to shore. When not in use, each STL Buoy will be lowered to rest on a landing pad on the ocean floor.

Port Ambrose is designed solely for the import of natural gas. Liberty will focus its deliveries through Port Ambrose during peak winter months to provide additional supplies of natural gas to downstate New York during periods of peak demand.

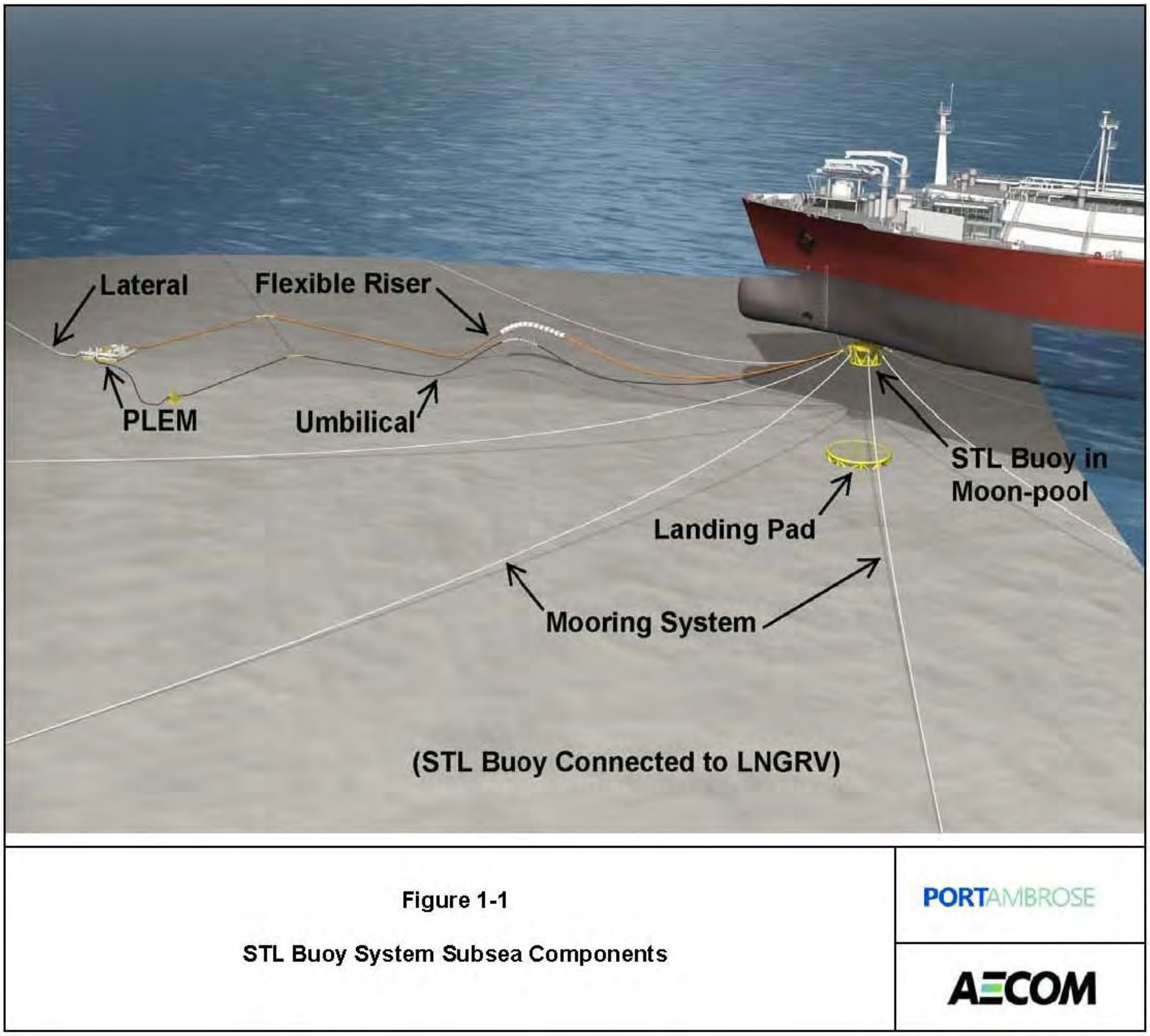


Figure 1-1 STL Buoy System

1.3 Construction phase

Construction of the Project, which will involve the fabrication and installation of STL Buoy systems 1 and 2, the accompanying Laterals, the Mainline, and two tie-in assemblies, is scheduled to be completed during a 20 month period spread over two calendar years. Off-site fabrication of components and related pre-construction activities are scheduled to commence in late 2015 and take approximately nine to twelve months to complete. Installation of offshore components is scheduled to begin in early 2016 and take approximately nine months to complete. Installation activities will be completed during late fourth quarter 2016, with the proposed Project scheduled to begin delivery of natural gas by the end of 2016.

1.4 Operational phase

The natural gas will be transported in a liquid state to Port Ambrose aboard LNGRVs. LNGRVs will approach the Port from the south using the Hudson Canyon to Ambrose traffic lane and depart using the Ambrose to Nantucket traffic lane.

During operation, the LNGRVs will regasify LNG and deliver natural gas to the Port. Upon arrival at the Port, each LNGRV will retrieve and connect to one of the two submerged STL Buoys. Once connected to a STL Buoy, the LNGRV will begin to vaporize the LNG using the on-board closed-loop shell and tube regasification system, and deliver natural gas at pipeline pressures through the STL Buoy system and Laterals to the Mainline.

The STL Buoys hold the LNGRVs on location throughout the unloading cycle by means of mooring lines secured to anchor points located on the seabed. The unloading duration is expected to be 5 to 16 days. Port Ambrose is designed for a two-buoy system where if required one LNGRV is moored and unloaded while another LNGRV is in transit or in the process of mooring or unmooring at the other STL Buoy. Upon completion of unloading, an LNGRV disconnects from the STL Buoy and departs to reload. This capability of overlapping sequence provides operational flexibility and can ensure uninterrupted, continuous flow of natural gas to the subsea pipeline system through the STL Buoys.

The Port will receive up to 45 LNGRVs per year. At nominal rate, the proposed Port facilities are designed to deliver an annual average of approximately 400 MMscf/d of natural gas at pipeline pressure. The maximum peak send-out for one STL Buoy is 650 MMscf/d. The maximum peak send-out for two STL Buoys is 660 MMscf/d.

1.5 Decommissioning phase

Upon the end of the useful life of the Project, Port Ambrose will be decommissioned. The Mainline and Laterals will be abandoned in place in accordance with 30 CFR 250, Subpart J and Q and 49 CFR Part 192. The Mainline will be abandoned in place and disconnected from all supply sources and gas delivery locations, depressurized, purged, filled with seawater, cut, and plugged with the ends buried. The hot-tap connection to the Transco Lower New York Bay Lateral will be sealed or capped to allow for continued operation of the Transco pipeline. The Laterals will be disconnected from the PLEM and the ends sealed or capped.

STL Buoys, PLEMs, flexible risers, and control umbilicals will be recovered from the site and demobilized to a central storage location onshore. The mooring chains and wire rope connecting the anchors to each STL Buoy will be recovered and demobilized to a central storage location onshore. The mooring piles will be inspected and recovered from the seafloor by reversing the installation process. A pump skid will be placed at the anchor pump nozzle utilizing remotely operated vehicles (ROVs) or a self-contained system that is operated from the surface via an umbilical. With pressure applied inside the anchor compartment the anchor will rise above the seabed, whereupon it will be lifted by a crane operating off of a heavy lift vessel and demobilized to shore. Alternatively, all portions protruding above the normal sea bed will be cut below the mud line, with the cut-off section recovered to the work barge/vessel and demobilized to shore for disposal.

Data on the abandoned pipeline facilities will be submitted to the Department of Transportation, Pipeline and Hazardous Material Safety Administration's National Pipeline Mapping System in accordance with 49 CFR § 192.727(g)(1).

1.6 Routine maintenance

During operation of the Port, it is anticipated that planned maintenance activities will occur on a routine basis. Routine maintenance activities are typically short in duration (several days or less) and require small vessels (less than 300 gross tons) to perform. Such activities include attaching/detaching and/or cleaning the buoy pick up line to the STL buoy, performing surveys and inspections with a ROV, and cleaning or replacing parts (e.g. bulbs, batteries, etc.) on the floating navigation (i.e., marker) buoys. Every seven to 10 years, an intelligent pig will be run down the Mainline and Laterals to assess the integrity of the pipeline system. This particular activity will require several large construction-type vessels and several weeks to complete.

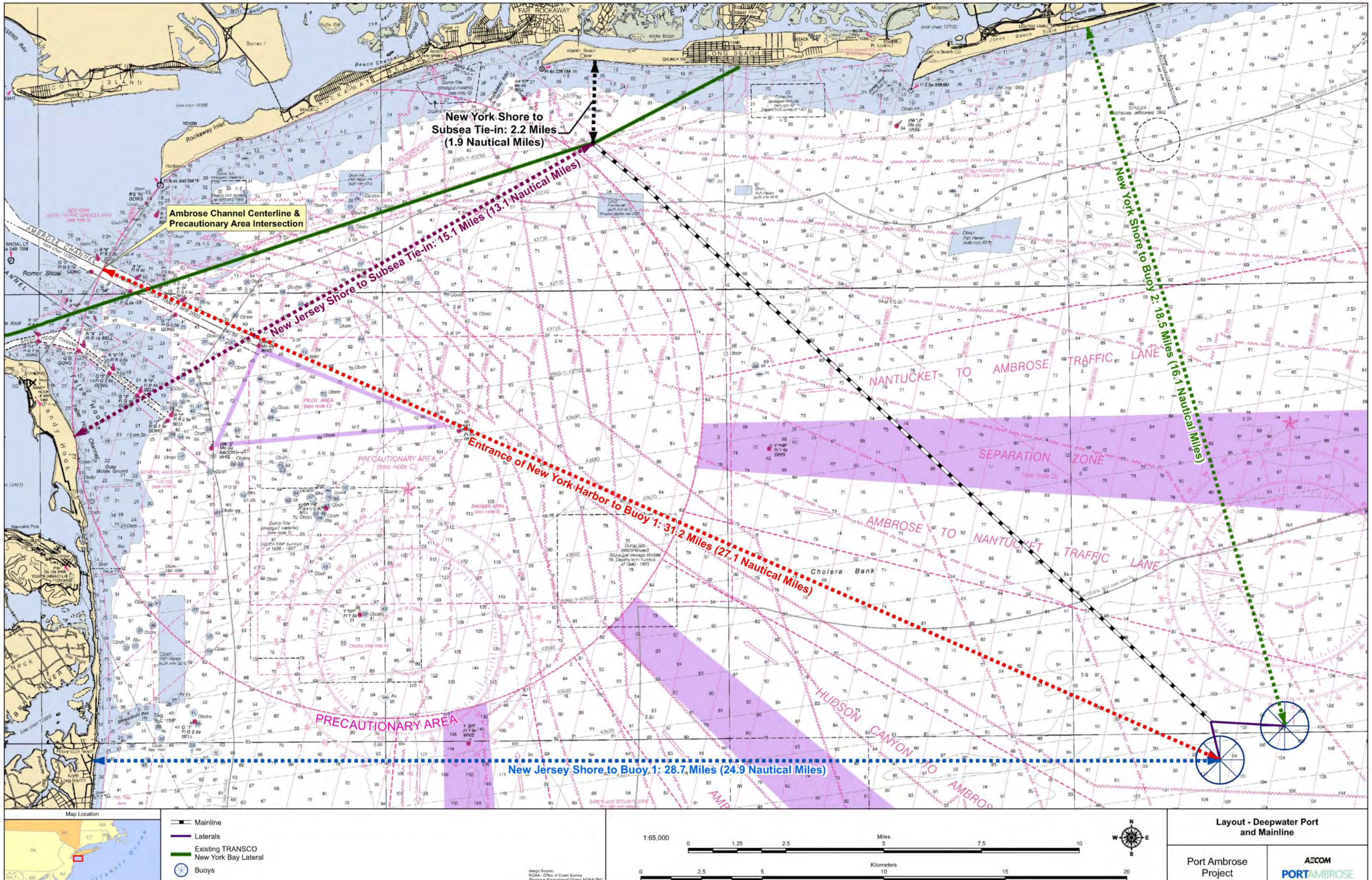
1.7 Unplanned events (non-routine repairs and unplanned incidents)

It is anticipated that repair activities will occur on a less frequent basis. While it is not possible to predict actual repair events, and dates and duration of these events, it is likely that some repairs will occur over the life of the Project. A description of these possible events is presented below.

Unplanned events can be either relatively minor, or in some cases, major requiring several large, construction-type vessels and an extensive mitigation program similar to that employed during the construction phase of the Project. Minor repairs are typically shorter in duration and could include fixing flanges or valves, replacing faulty pressure transducers, or repairing a stuck valve. These kinds of repairs would require one diver support vessel and could take from a few days to several weeks depending on the nature of the problem.

Major repairs and unplanned incidents, on the other hand, would be longer in duration and typically require large construction vessels similar to those used to install the pipeline and set the buoy and anchoring system. These vessels would typically mobilize from local ports, Canada, or the Gulf of Mexico. Major repairs would typically require upfront planning, equipment procurement, mobilization of vessels and possibly saturation divers. Examples of major repairs, although unlikely to occur, are damage to the riser or umbilical line and their possible replacement, damage to the pipeline system and manifolds, or anchor chain replacement. These types of repairs could take two to four weeks or possibly longer.

Figure 1-2 Location map



2.0 Underwater Noise Overview

2.1 Nature of underwater sound

Sound is an acoustic pressure wave that travels through a medium, such as water or air, and occurs as an oscillatory motion of the water or air particles driven by a vibrating source. The magnitude of the water or air particle motion determines the intensity of the sound. The rate at which the water or air particles oscillate determines its frequency, given in cycles per second or Hertz (Hz).

Sound travels about four-and-a-half times faster in water than in air. The absorption of sound at frequencies where man-made noise generally has the most energy is much smaller in water than in air. As a result, noise is typically audible over much greater ranges underwater than in air. Most sources of noise, including movement of large shipping vessels generate acoustic energy over a broad range of frequencies. Screeching or whistling noises are composed mainly of high frequency sounds while rumbles or booms are composed mainly of low frequency sounds.

Sounds are usually characterized according to whether they are continuous or impulsive in character. Continuous sounds occur without pauses and examples include shipping noise and dredging. Impulsive sounds are of short duration and can occur singularly, irregularly, or as part of a repeating pattern. Blasting represents a single impulsive event whereas the periodic impacts from a pile driving rig results in a patterned impulsive sequence. Impulsive signals typically sound like bangs and generally include a broad range of frequencies.

Sound pressures are measured with a hydrophone when underwater and a microphone when in air. The international standard unit of sound pressure is the Pascal (Pa). Sound pressures encountered underwater and in air range from levels just detectable by the mammal ear (hundreds of micro Pascals (µPa)) to much greater levels causing hearing damage (billions of Pa). Because this range is so enormous, sound pressure is normally described in terms of a sound pressure level (SPL) with units of decibel (dB) referenced to a standard pressure of 1 µPa for underwater and 20 µPa for airborne acoustics.

2.2 Underwater noise metrics

Underwater noise metrics commonly used for presenting source, measured or received underwater noise levels include the following:

- *Sound pressure level* (SPL) – Sound pressure is expressed in units of dB re 1 µPa, and in underwater noise is often averaged over a measurement period or provided as a peak level.
  - Continuous sources such as shipping noise and dredging are commonly characterized in terms of a root mean square SPL (denoted dB_{rms}) averaged over the measurement period.
  - Impulsive sources are often characterized in terms of the peak level (denoted dBpeak), which is the highest sound pressure over the measurement period.
- *Sound exposure level* (SEL) – Sound energy over the measurement period expressed as an equivalent sound level for a 1-second exposure period, expressed in units of dB re 1 µPa2s. The SEL is commonly used for impulsive sources because it allows a comparison of the energy contained in impulsive signals of different duration and peak levels. The measurement period for impulsive signals is usually defined as the time period containing 90% of the sound energy.
- *Source level* –The source level is defined as the sound pressure (or energy) level that would be measured at 1 m from an ideal point source radiating the same amount of sound as the actual

source being measured. The intensity of underwater noise sources is compared using the source level (SL) expressed in units of dB re 1 µPa at 1 m.

SPLs and SELs can be presented either as overall levels or as frequency dependent spectral or third-octave band levels indicating the frequency content of a source. Overall SPLs and SELs present the total average noise and energy level, respectively, within a given frequency bandwidth – usually the band that contains most of the energy. Spectral density levels are expressed in units of dB re 1 µPa2/Hz and provide a greater frequency resolution than third-octave band levels, which are expressed in units of dB re 1 µPa.

2.3 SEL accumulation time

SEL is a noise descriptor typically used to provide a comparative measure of sound levels from sources of different durations. SEL achieves this by converting noise levels occurring over varying exposure periods to equivalent sound levels with a standard reference time, which is typically one second. It can be thought of as incorporating all the acoustic energy emitted by a source over a time period into an equivalent noise level for a one second period.

Underwater noise sources have significant variation in their duration. For example, impact piling typically consists of short pulses of noise from hammer impacts which occur for 1-2 hours, whereas noise from vessel movements is typically a steady noise level occurring for the duration of transit. SEL is a descriptor which allows for comparison of the noise levels from these different sources.

Noise from an impact piling source can be considered on a per-impact time period (approximately 0.1 seconds for 90% of the impact sound energy) or as a cumulative exposure to noise from multiple impacts over the course of pile installation. SEL can therefore be presented as a SEL per-impact level or as a cumulative level for a chosen accumulation time.

We have distinguished cumulative SEL levels in this report by using the subscript ‘c’ (SEL_c). We note that JASCO uses the terminology cSEL in their reporting to represent the same metric.

2.4 Project specific sources of underwater noise

Underwater noise generation is likely to occur during construction and operations phases (including normal operations and routine maintenance), decommissioning and during unplanned events (e.g., unplanned repairs or incidents).

On-site construction is to be undertaken between May and October 2016 during favorable weather conditions. During the construction phase, each STL buoy’s permanent mooring system will require the installation of eight suction piles (anchors). While suction piles are the preferred and planned anchoring system, impact piles would be only be used if absolutely necessary, based on deep geotechnical boring data and design considerations.

Because impact piling was assessed to have the highest potential for sound generation associated with the proposed Project, a technical feasibility study was conducted to determine if suction pilling was a possible alternative to impact piling (Moffatt and Nichol 2014). According to the Design and Installation Concept Verification study by Moffatt and Nichol (2014), it is expected that the anchors can be installed in the sandy ground conditions and water depths anticipated at the Port Ambrose deepwater port site using suction piles. Although underwater sound measurements of suction pile installations are not available, it is expected that the noise from this method of anchor placement would be negligible because the only noise source is the suction pump (Spence et al. 2007). All impulsive type sounds are removed using this approach (CSA Ocean Sciences Inc. 2014).

If suction piles cannot be used during the construction phase of the Project, impact piling may be considered. If the unlikely alternative method of impact piling is necessary, noise from impact piling will be considerably louder than the ambient underwater noise environment in the vicinity of the piling, and will dominate any other underwater noise from simultaneous construction activities. In the unlikely event that impact piling is used for the Project, the proposed duration of pile driving has been estimated to be approximately 2.5 hours per pile, or 40 hours total for the 16 piles.

Construction of the Mainline to connect with the Lower New York Bay Lateral will potentially create underwater noise during pipeline installation, interconnection and lowering/backfilling. Pipeline construction will utilize a pipe lay vessel, plow vessel, and a dive support vessel. A jet plow is proposed for an approximate 3-mile Mainline section just north of the Nantucket to Ambrose traffic lane.

Port Ambrose will be operational all year long; however LNG, RV and regasification activities will predominantly occur during winter during the peak of the heating season. Underwater noise is anticipated to be produced by the LNGRVs during the approach, mooring, maneuvering on the buoy and regasification procedures. A standby Support Vessel will also be located in close proximity to the LNGRVs during mooring and regasification. The highest-energy source of underwater sound during the operation phase will be from vessel transits near the Port and from mooring activities. The Project is to be constructed approximately 30 miles offshore of the Port of New York and New Jersey, which is considered the third busiest port in the United States. Vessel sounds during operations will result from propeller cavitation and propulsion, in addition to flow noise from water dragging across the hull and bubbles breaking in the wake. The dominant sound source from vessels is propeller cavitation with noise intensity dependent upon size and speed of the vessel (BOEMRE 2009). Noise impacts from LNGRVs are expected to be comparable to those generated by common and existing vessel traffic in the New York Bight. Underwater sound generated from routine maintenance, decommissioning and unplanned events will be similar to those from the construction and operations phase of the Project and as such were not modeled by JASCO as unique sound sources (2014). Because these activities utilize similar equipment (e.g. support vessels) with similar sound sources for a shorter duration, they are not discussed further.

2.5 Existing underwater noise environment

The level and frequency characteristics of the ambient noise environment are two factors that control how far away a given noise source can be detected (Richardson et al. 1995). In general, noise is only detectable if it is within the audible hearing range of the receiver, and of a higher level than the ambient noise environment at similar frequencies. A lower ambient noise environment results in audible noise out to greater ranges before diminishing below the background noise level. The potential zone in which noise emissions from a source are detectable depends on the levels and types of ambient noise in the waters surrounding the noise source.

The main sources of ambient noise in the ocean are man-made sources such as shipping and sonar activity, and environmental sources such as wind-dependent noise and biological noise. Other environmental sources include surf noise typically localized near the coast, precipitation noise from rain and hail, seismic noise from volcanic and tectonic activity, and thermal noise (Wenz 1962).

Between 500 Hz and 100 kHz, the ambient environment is typically dominated by wind and wave noise where the noise levels tend to increase with increasing wind speed. Ambient ocean noise due to wind and waves is often described in relation to sea state. Wenz (1962) determined an empirical rule as an approximation for spectrum levels of wind-dependent ambient noise. Between 500 Hz and 5 kHz, spectrum levels decrease 5 dB per octave with increasing frequency, and increase 5 dB with each doubling of wind speed from 5 to 75 km/h. The spectrum level at 1 kHz in shallow water is 56 dB re 1 μPa2/Hz when the wind speed is 9 km/h (Beaufort sea state two). In an open ocean environment, sea states of greater than four are common, resulting in wind-dependent ambient overall noise levels of 100–120 dB re 1 μPa.

The main sources of ambient underwater noise in the waters surrounding the Port and Laterals are likely to be shipping noise from the Port of New York and New Jersey, wind-dependent noise, precipitation noise and surf noise in the regions closer to shore. Of these sources, shipping noise is considered to be the dominant source, with the Port located approximately 2.5 km from the closest traffic lane (Ambrose to Nantucket Traffic Lane), and 50 km to the entrance of New York Harbor, as shown in Figure 1-1. The Port of New York and New Jersey is considered the third busiest Port in the U.S. by total vessel calls, with the most common vessel types being container ships, tankers, and roll on/roll off vessels (U.S. Department of Transportation Maritime Administration 2013). Surface shipping is the most widespread source of anthropogenic, low frequency (0 to 1,000 Hz) noise in the oceans (Simmonds and Hutchinson 1996). Source levels for commercial ships range from 180-195 dB re 1 µPa which dominate underwater noise in the 10-500 Hz frequency bands (NRC 2003, Hildebrand 2009, McKenna et al. 2012).

3.0 Law and Policy

3.1 ESA and MMPA

The most relevant laws that need to be considered when assessing the impacts of underwater sound on marine fauna are the ESA and MMPA. The ESA protects all endangered and threatened species from extinction, while marine mammals have the additional protection of the MMPA.

3.1.1 Endangered Species Act of 1973

The ESA's purpose is to prevent the extinction of imperiled flora and fauna by protecting both the species and its environment from harm. To qualify for protection, a species must be formally listed under the ESA. The ESA is administered by two federal agencies, the National Oceanic and Atmospheric Administration (NOAA) and the United States Fish and Wildlife Service (USFWS).

Under the ESA, "take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. Of these forms of take, harassment and harm are most relevant to underwater noise. The term "harm" is defined under the ESA as "any act which actually kills or injures fish or wildlife" [30 CFR Part 222, 1999 amendment]. USFWS defines ESA "harassment" as an action that creates the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to breeding, feeding or sheltering.

Section 9 of the ESA prohibits the incidental take of ESA-listed species. Section 7 of the ESA requires that all federal agencies consult with the USFWS or NOAA Fisheries, as applicable, before initiating any action that could affect a listed species. Through the Deepwater Port application review process, the permitting agency is required under the ESA to consult with USFWS or NOAA to evaluate the direct and indirect effects on federally listed threatened and endangered species and their critical habitat, using the best scientific and commercial data available. If it is concluded that the Project is likely to adversely affect listed species or their habitats, the authorizing agency must request consultation with the USFWS and/or NOAA Fisheries. After consultation, USFWS and/or NOAA Fisheries will prepare a biological opinion (BO) on whether the proposed activity will jeopardize the continued existence of a listed species. If the agencies' opinion is that the Project is likely to jeopardize the continued existence of a listed species or habitat, they may issue an incidental take statement, provided that reasonable and prudent measures are designed to minimize the impact of incidental take that might otherwise result from the proposed action.

3.1.2 Marine Mammal Protection Act of 1972

The MMPA protects all marine mammal species within the United States. The MMPA is administered by NOAA and the USFWS. Under the MMPA, the term "take" means to harass, hunt, capture, or kill, or attempt to harass, hunt, capture or kill any marine mammal.

The MMPA prohibits the take of marine mammals, with certain exceptions; including the issuance of incidental take authorizations (ITAs) and Letters of Authorization (LOAs), or Incidental Harassment Authorizations (IHAs) to incidentally take small numbers of marine mammals by "harassment." Sections 101(a)(5)(A) & (D) of the MMPA direct the Secretary of Commerce (or Secretary of Interior for some species) to allow, upon request, the incidental, but not intentional, taking of small numbers of marine mammals by U.S. citizens who engage in a specified activity (other than commercial fishing) within a specified geographical region if certain findings are made. Through delegation by the Secretary of Commerce, NMFS may authorize the incidental taking of marine mammals if it finds that the total taking will have a negligible impact on the species or stock(s). NMFS must also set forth the permissible methods of taking and requirements pertaining to the mitigation, monitoring and reporting of such takings.

Two levels of harassment (relative to take) are defined under the MMPA: Level A Harassment (“harm”) and Level B Harassment (“harassment”). Level A Harassment is defined as any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild. Level B Harassment is defined as any act of pursuit, torment, or annoyance which disturbs a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but which does not have the potential to injure a marine mammal or marine mammal stock in the wild.

3.2 Policy and guidance documents

3.2.1 NOAA draft guidance for assessing the effects of anthropogenic sound on marine mammals

NOAA released a draft document entitled *Draft Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammals* (Draft Guidance). The Draft Guidance was open for public comment up until 14 March 2014, and is anticipated to be finalized and released formally sometime this year. When finalized, the Draft Guidance is intended to be used as a tool to assess impacts of anthropogenic sound on marine fauna under the jurisdiction of the NMFS. It provides objective noise levels for which individual marine mammals are predicted to experience change in their hearing sensitivity, and is intended to be used by NOAA and other relevant stakeholders when seeking to determine the impact of activities on marine mammals from underwater noise generation.

In the Draft Guidance, NOAA equates the onset of Permanent Threshold Shift (PTS) with “harm” as defined in the ESA, and with “Level A Harassment” as defined in the MMPA. As such, PTS is considered equivalent to these two types of takes. NOAA equates Temporary Threshold Shift (TTS) as “harassment” as defined under the ESA and “Level B Harassment” as defined in the MMPA. It is worth noting that NOAA also considers behavioral changes to constitute “harassment” and “Level B Harassment”; however, objective criteria for assessing behavioral change in marine mammals have not yet been finalized.

3.2.2 California Department of Transportation Fisheries Hydro-acoustic Working Group interim criteria

Research studies and/or acoustic guidance or regulations related to fish and underwater sound is lacking. The California Department of Transportation established a Fisheries Hydro-acoustic Working Group (FHWG) to develop interim noise exposure criteria for injury to fish from pile driving. The FHWG consists of key technical and policy staff from the U.S. Federal Highway Administration (FHWA), NOAA Fisheries, Fish and Wildlife Service (USFWS), various Departments of Transportation, and national experts on the effects of underwater noise on fish.

The FHWG has produced a number of publications (Hastings and Popper 2005, Popper et al. 2006, Carlson et al. 2007, Buehler et al. 2007) culminating in an Agreement in Principle by the signatory agencies to interim criteria for injury to fish from pile driving activities (FHWG 2008). The interim criteria address three major effects including non-auditory tissue damage, auditory tissue damage and TTS. Because of the lack of federal guidance on this issue and unlikely use of pile driving for the Project we are utilizing the FHWG criteria to discuss potential impacts of underwater sound on endangered fish species in the Project area as a general reference to sound sources.

4.0 Key Biological Resources

This section outlines the species that have been identified as likely to occur in the proposed Project area and are listed under the ESA as threatened or endangered, or protected under the MMPA. Details of species abundance were provided in the Deepwater Port License Application Environmental Evaluation Topic Report 4 –Biological Resources. NOAA also provided information on listed species' of concern in their letter to Liberty dated 12 August 2013, included in this document as Appendix A.

4.1 Marine mammals

In the western North Atlantic Ocean, 31 species of marine mammals have been observed. Table 4-1 lists these species along with their listing status (ESA and MMPA status), and expected occurrence in the vicinity of the Project (both Port and Mainline). Of the 31 species of marine mammals observed in the western North Atlantic Ocean only nine species (three whales, two dolphins, one porpoise, and three seals) are thought to occur in the Project area; with the three whales listed as endangered under the ESA.

Twenty-six of these 31 mammal species occurring in the western North Atlantic Ocean belong to the Order Cetacea. Of these cetaceans, six belong to the suborder Mysticeti (baleen whales), and the remaining 20 belong to the suborder Odontoceti (toothed whales and dolphins). There are six whale species listed under the ESA as endangered that transit the NY Bight area, including the following species: fin whale (*Balaenoptera physalus*), blue whale (*Balaenoptera musculus*), humpback whale (*Megaptera novaeangliae*), North Atlantic right whale (*Eubalaena glacialis*), Sei whale (*Balaenoptera borealis*), and sperm whale (*Physeter macrocephalus*). In addition to these listed species, several dolphin species protected under the MMPA have been sighted in the vicinity of the NY Bight (USFWS 1997), or have stranded along the New York Coastline (NOAA/NMFS 2001).

The NY Bight area is also important wintering habitat for four species of seals, all of which are protected under the MMPA, including: harbor seals, gray seals, harp seals, and hooded seals (USFWS 1997). Harbor seals (*Phoca vitulina*) are the most common seals along the U.S. east coast (NOAA/NMFS 2008c) and the New York Bight is a significant wintering area for harbor seals, including several haul-out locations along the beaches of Long Island (NYSDEC 2012d, CRESLI 2012b).

Species known to occur in the Western North Atlantic Region are presented in Table 4-1. Because many of the species listed only transit the area, occur in deeper water, or occur rarely, it is expected that many of them will not occur in the Project area (Port or Mainline). Section 4.1.1 provides a detailed description of the six ESA listed marine mammals that could transit the NY Bight area during construction or operations of the Port. Only three of these (fin whale, humpback whale, and North Atlantic right whale) are expected to occur in the Project area (Port or Mainline) (NOAA 2013). The other three ESA-listed species of Mysticete whales and one endangered species from the Order Sirenia, the West Indian manatee, are not expected in the Project (Port or Mainline) area.

According to a letter dated August 12, 2013 by NOAA, provided in Appendix A, the federally listed cetacean species possibly occurring in the Project area are the North Atlantic right whale, humpback whale and fin whale. These species are seasonally present in waters off New York and New Jersey, using the area as a migration route. The North Atlantic right whale occurs in waters from November through April (with the exception of transient whales during other times), while Humpback and Fin whales more commonly transit the area from September through May (see additional details below).

In addition to the description of endangered whales, this assessment also provides a short overview of the 24 additional species of marine mammals protected under the MMPA in Section 4.1.2 that are known to occur in the NY Bight area. Only six of these marine mammal species have the potential to transit the Project area (Port and Mainline):

- harbor porpoise (*Phocoena phocoena*),
- bottlenose dolphin (*Tursiops truncatus*),
- common dolphin (*Delphinus delphis*),
- harbor seal (*Phoca vitulina*),
- gray seal (*Halichoerus grypus*), and
- harp seal (*Pagophilus groenlandicus*).

Table 4-1 Marine mammals documented to occur in the north western Atlantic Ocean and their expected occurrence in the Project Area

Common Name	Scientific Name	Regulatory Status (ESA, MMPA)	N.Y. Bight Status	Expected Occurrence in Project Area
Order Cetacea				
Suborder Mysticeti (baleen whales)				
Blue whale	*Balaenoptera musculus*	ESA (Endangered), MMPA (Protected)	R, S	**Not expected to occur (highly unlikely).** Prefer deeper and more northern waters.
Fin whale	*Balaenoptera physalus*	ESA (Endangered), MMPA (Protected)	A, S	**Possible occurrence within the Port and Mainline area**, especially in winter/early spring or perhaps fall.
Humpback whale	*Megaptera novaeangliae*	ESA (Endangered), MMPA (Protected)	C, S	**Possible occurrence within the Port and Mainline area.** Prefer deeper water during migrations, but transients possible in shallower waters of N.Y. Bight in fall-spring.
North Atlantic right whale	*Eubalaena glacialis*	ESA (Endangered), MMPA (Protected)	R, S	**Possible (rare) occurrence in the Mainline area.** Observed in mid-Atlantic waters and New York Bight during northward spring migrations and possibly fall (November-April).
Sei whale	*Balaenoptera borealis*	ESA (Endangered), MMPA (Protected)	R, S	**Not expected to occur (highly unlikely).** Prefer deep waters of continental shelf edge and seaward.
Minke whale	*Balaenoptera acutorostrata*	MMPA (Protected)	A, S	**Not expected to occur (unlikely)**. Prefer deeper continental shelf waters.

Common Name	Scientific Name	Regulatory Status (ESA, MMPA)	N.Y. Bight Status	Expected Occurrence in Project Area
Suborder Odontoceti (toothed whales and dolphins)				
Sperm whale	*Physeter macrocephalus*	ESA (Endangered), Strategic	C, S	**Not expected to occur (unlikely).** Prefer deeper continental shelf waters.
Pygmy sperm whale	*Kogia breviceps*	MMPA (Protected)	C, UNK	**Not expected to occur (unlikely).** Prefer deeper waters seaward of continental shelf.
Dwarf sperm whale	*Kogia simus*	MMPA (Protected)	C, UNK	**Not expected to occur (unlikely).** Prefer deeper waters of continental shelf edge and slope.
Long-finned pilot whale	*Globicephala melas*	MMPA (Protected)	A, UNK	**Not expected to occur (unlikely).** Prefer deeper waters of the continental shelf edge and seaward.
Cuvier's beaked whale	*Ziphius cavirostris*	MMPA (Protected)	UNK	**Not expected to occur (unlikely).** Prefer deeper waters of the continental shelf edge.
Mesoplodon beaked whale	*Mesoplodon* spp.	MMPA (Protected)	UNK	**Not expected to occur (unlikely).** Prefer deeper waters of the continental shelf edge.
Killer whale (Orca)	*Orcinus orca*	MMPA (Protected)	R, UNK	**Not expected to occur (unlikely)** due to its rarity in this portion of the Atlantic.
Pygmy killer whale	*Feresa attenuata*	MMPA (Protected)	R, UNK	**Not expected to occur (unlikely)** due to its rarity in this portion of the Atlantic.
False killer whale	*Pseudorca crassidens*	MMPA (Protected)	UNK	**Not expected to occur (unlikely).** Prefers deeper waters (>1000 m).
Melon-headed whale	*Peponocephala electra*	MMPA (Protected)	UNK	**Not expected to occur (highly unlikely).** Prefers deeper and warmer waters.
Risso's dolphin	*Grampus griseus*	MMPA (Protected)	A, UNK	**Not expected to occur (unlikely).** Prefers deeper waters (>1000 m).
Bottlenose dolphin	*Tursiops truncatus*	MMPA (Protected)	A, S	**Possible occurrence within the Port and Mainline area** May through October.
Common dolphin	*Delphinus delphis*	MMPA (Protected)	A, UNK	**Possible occurrence within the Port and Mainline area,** especially in winter or spring.
Striped dolphin	*Stenella coeruleoalba*	MMPA (Protected)	A, S	**Not expected to occur (unlikely).** Prefer deeper continental shelf waters.

Common Name	Scientific Name	Regulatory Status (ESA, MMPA)	N.Y. Bight Status	Expected Occurrence in Project Area
Clymene dolphin	*Stenella clymene*	MMPA (Protected)	UNK	**Not expected to occur (highly unlikely).** Prefer deeper (>250 m) and warmer waters.
Atlantic spotted dolphin	*Stenella frontalis*	MMPA (Protected)	A, S	**Not expected to occur (unlikely).** Prefer deeper waters near the shelf edge.
Spinner dolphin	*Stenella longirostris*	MMPA (Protected)	UNK	**Not expected to occur (unlikely).** Prefer deeper waters (>2000 m).
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	MMPA (Protected)	A, Y	**Not expected to occur (unlikely)** due to low abundance.
White-beaked dolphin	*Lagenorhynchus albirostris*	MMPA (Protected)	UNK	**Not expected to occur (unlikely).** Prefer colder waters, further north.
Harbor porpoise	*Phocoena phocoena*	MMPA (Protected)	I, S	**Possible occurrence within the Mainline and Port Area,** in the spring and summer months.
Order/Suborder/Superfamily Carnivora/Caniformia/Pinnipedia (pinnipeds)				
Harbor seal	*Phoca vitulina*	MMPA (Protected)	A, ES	**Possible occurrence in the Project area.** New York Bight is a significant wintering area for species so could transit the Project area from Sept. - May.
Gray seal	*Halichoerus grypus*	MMPA (Protected)	I, ES	**Possible occurrence in the Project area.** Prefers more northern waters, but could transit the Project area from Sept. - May.
Harp seal	*Pagophilus groenlandicus*	MMPA (Protected)	I, S	**Possible occurrence in the Project area.** Prefers more northern waters, but could transit the Project area from Sept. - May.
Hooded seal	*Cystophora cristata*	MMPA (Protected)	R, S	**Not expected to occur (unlikely).** Prefers deeper waters, but rare transients possible.

Common Name	Scientific Name	Regulatory Status (ESA, MMPA)	N.Y. Bight Status	Expected Occurrence in Project Area
Order/Family Sirenia/Trichechidae (Sirenians)				
West Indian Manatee	*Trichechus manatus*	ESA (Endangered), MMPA (Protected)	R, S	**Not expected to occur (highly unlikely).** Prefers warmer waters, but very rare transients possible.
Sources: ACS (2008) NOAA/NMFS (2008a) NOAA/NMFS (2008b) Read et al. (2008) USFWS (2011) Waring et al. (2013) Neubert and Sullivan (2014) **Key:** A=Abundant, C=Common, I=Increasing in presence, R=Rare, UNK=Unknown, Y= Year-round, S=Seasonal, ES=Extended seasonal				

4.1.1 Marine mammals listed as endangered that occur in the northwestern Atlantic Ocean

4.1.1.1 Blue whale (*Balaenoptera musculus*) – Endangered

At least three subspecies of blue whales have been identified based on body size and geographic distribution of which *B. musculus musculus* occurs in the Northern Hemisphere. In the western North Atlantic Ocean, blue whales are found from the Arctic to at least the mid-latitude waters of the North Atlantic (CeTAP 1982, Wenzel et al.1988, Yochem and Leatherwood 1985, Gagnon and Clark 1993).

The size of the blue whale population in the North Atlantic is uncertain. The population has been estimated to be from a few hundred individuals (Allen 1970, Mitchell 1974) to 1,000 to 2,000 individuals (Sigurjónsson 1995). Sears et al. (1987) identified over 300 individual blue whales in the Gulf of St. Lawrence, which provides a minimum estimate for their population in the North Atlantic, and some speculate that there may be between 400 and 600 blue whales in the western North Atlantic (Mitchell 1974, Waring et al. 2011).

Direct studies of whale hearing have not been conducted for most species of large whales, but it is assumed that they can hear at the same frequencies that they vocalize (10-100Hz for blue whales) and are likely to be most sensitive at that range (Ketten 1997). A more recent study of blue whales observed responses to mid-frequency sonar signals in the 1-8 kHz range (Melcón et al. 2012).

The two main anthropogenic threats to blue whales are whaling and shipping. Historically, whaling represented the greatest threat to every population of blue whales and was ultimately responsible for listing blue whales as an endangered species. In the Eastern North Pacific, ship strikes were implicated in the deaths of five blue whales, from 2004- 2008 (Caretta et al. 2011). No confirmed ship strikes of blue whales were recorded in the North Atlantic or Gulf of Mexico between 2006 and 2010 (Henry et al. 2012).

Blue whales are <u>not likely (highly unlikely) to occur</u> in the Project area.

4.1.1.2 Fin whale (*Balaenoptera physalus*) – Endangered

Fin whales have two recognized subspecies: *Balaenoptera physalus physalus* (Linnaeus 1758) which occurs in the North Atlantic Ocean; and *B. p. quoyi* (Fischer 1829) which occurs in the Southern Ocean. Globally, fin whales are sub-divided into three major groups: Atlantic, Pacific, and Antarctic. Fin whales are widely distributed and occur in every ocean except the Arctic Ocean. In the North Atlantic Ocean, fin whales occur in summer foraging areas from the coast of North America to Greenland, Iceland, northern Norway and the Barents Sea to the Arctic. In winter, they can be found from the edge of sea ice in the North to as far south as the Gulf of Mexico and the West Indies in the Western Atlantic Ocean.

Fin whales are common off the Atlantic coast of the United States in waters immediately off the coast to the continental shelf. During the summer months, fin whales tend to congregate in feeding areas between 41°20'N and 51°00'N, from shore seaward to the 1,000 fathom contour (NOAA 2013). They are less concentrated in the nearshore environment than Humpback or North Atlantic right whales. In the Atlantic Ocean, fin whale migration in the fall occurs from the Labrador and Newfoundland region, south past Bermuda, and into the West Indies (Clark et al. 2002). The overall distribution of fin whales may be, at least in part, based on prey availability, as this species feeds by filtering large volumes of water for both invertebrates and fish (Watkins et al. 1984). Abundance estimates for the Western North Atlantic stock is 2,269 (CV = 0.37) (NMFS 2010), with a minimum population estimate of 1,678 (Waring et al. 2009).

Fin whales produce a variety of low-frequency sounds in the 10-200 Hz band (Watkins 1981, Watkins et al. 1987, Edds 1988, Thompson et al. 1992). As with other vocalizations produced by baleen whales, the function of fin whale vocalizations is unknown, although there are numerous hypotheses about the reasons for vocalizations. Some hypotheses for these vocalizations include: maintaining distance, species and individual recognition, information transmission, maintenance of social organization, location of topographic features, and location of prey resources (Thompson et al. 1992, NOAA 2013).

The three greatest anthropogenic stressors to fin whales are whaling, commercial fishing, and vessel strikes. It is thought that fin whales are killed and injured in collisions with vessels more frequently than any other whale in U.S. waters (NOAA 2013). Of 92 fin whales that stranded along the Atlantic Coast of the U.S. between 1975 and 1996, 31 (33%) showed evidence of collisions with ships (Laist et al. 2001). Between 1999 and 2005, there were fifteen reports of fin whales being struck by vessels along the Atlantic Coast of the U.S. and the Maritime Provinces of Canada (Cole et al. 2005, Nelson et al. 2007). Of these reports, thirteen were confirmed as ship strikes which were reported as having resulted in the death of eleven fin whales.

Because fin whales are common in waters immediately off the Atlantic coast to the continental shelf, fin whales transiting through the area <u>could occur</u> in the Project area (Port and Mainline) during migrations.

4.1.1.3 Humpback whale (*Megaptera novaeangliae*) – Endangered

Humpback whales occur in the Atlantic, Indian, Pacific, and Southern Oceans. They migrate seasonally between tropical or sub-tropical waters in winter months where they reproduce; and temperate or sub-Arctic waters where they feed in summer months. In their summer foraging areas and winter calving areas, humpback whales tend to occupy shallower, coastal waters; during their seasonal migrations, however, humpback whales disperse widely in deep, pelagic waters and tend to avoid shallower coastal waters (Winn and Reichley 1985).

In the Atlantic Ocean, humpback whales range from the mid-Atlantic bight, the Gulf of Maine, across the southern coast of Greenland and Iceland, and along the coast of Norway in the Barents Sea. These whales migrate to the western coast of Africa and the Caribbean Sea during the winter. In the Atlantic Ocean, humpback whales aggregate in four feeding areas in the summer months: (1) Gulf of Maine; (2) western Greenland; (3) Iceland; and (4) Norway (Katona and Beard 1990, Smith et al. 1999). The principal breeding range for these whales lies from the Antilles and northern Venezuela to Cuba (Winn et al. 1975, Balcomb and Nichols 1982, Whitehead and Moore 1982). Stevick et al. (2003) estimated the size of the North Atlantic humpback whale population to be between 5,930 and 12,580 individuals and current estimates suggest that the global population of humpback whales consists of tens of thousands of individuals (NOAA 2013).

Humpback whales produce at least three kinds of vocalization: (1) complex songs with components ranging from at least 20Hz to 4 kHz (Payne 1970, Winn et al. 1970, Richardson et al. 1995); (2) social sounds in breeding areas that extend from 50 Hz to more than 10 kHz (Tyack and Whitehead 1983, Richardson et al. 1995); and (3) vocalizations in foraging areas that are less frequent, but tend to be 20Hz to 2 kHz (Thompson et al. 1986, Richardson et al. 1995). Based on mathematical models it is thought that humpback whales are sensitive to sound in frequencies ranging from 0.7 kHz to 10 kHz, with a maximum sensitivity between 2 and 6 kHz (Helwig et al. 2000).

Historically, whaling represented the greatest threat to humpback whales and was ultimately responsible for listing the species as endangered. Humpback whales are also killed or injured during interactions with commercial fishing gear and by vessel strikes. Along the Atlantic Coast of the U.S. and the Maritime Provinces of Canada, there were 101 confirmed entanglement events between 2006 and 2010 (Henry et al. 2012). Of these, 20 resulted in serious injury and 9 resulted in mortality of humpbacks. As of 2008, there were more than 143 recorded ship strikes involving humpback whales worldwide (Van Waerebeek and Leaper 2008), and many more might go undetected or unreported.

Humpback whales that transit the area <u>could occur</u> in the Project area (Port or Mainline) during migrations in the fall and spring.

4.1.1.4 North Atlantic right whale (*Eubalaena glacialis*) – Endangered

NOAA Fisheries recognizes two extant groups of right whales in the North Atlantic Ocean (*E. glacialis*): an eastern population and a western population. In the western Atlantic Ocean, North Atlantic right whales generally occur in northwest Atlantic waters west of the Gulf Stream and are most commonly associated with cooler waters (21°C). North Atlantic right whales are most abundant in Cape Cod Bay between February and April (Hamilton and Mayo 1990, Schevill et al. 1986, Watkins and Schevill 1982), in the Great South Channel in May and June (Kenney et al. 1986, Payne et al. 1990) and off Georgia and Florida from mid-November through March (Slay et al. 1996). North Atlantic right whales use mid-Atlantic waters as a migratory pathway between the winter calving grounds and their spring and summer nursery feeding areas in the Gulf of Maine.

Kraus et al. (2005) estimated that about 350 individual right whales, including about 70 mature females, occur in the western North Atlantic. The western North Atlantic population numbered at least 361 individuals in 2005 and at least 396 in 2007 (Waring et al. 2012).

North Atlantic right whales produce a variety of sounds, including moans, screams, gunshots, blows, upcalls, downcalls and warbles that are often linked to specific behaviors (Matthews et al. 2001, Laurinolli et al. 2003, Vanderlaan et al. 2003, Parks et al. 2005, Parks and Tyack 2005). Sounds can be divided into three main categories: (1) blow sounds; (2) broadband impulsive sounds; and (3) tonal call types (Parks and Clark 2007). Most of these sounds range in frequency from 0.02 to 15 kHz. Recent analyses of North Atlantic right whale inner ears estimates a hearing range of approximately 0.01 to 22 kHz based on established marine mammal models (Parks et al. 2004, Parks and Tyack 2005, Parks et al. 2007).

Several human activities are known to threaten North Atlantic right whales, including: whaling, commercial fishing and shipping. Historically, whaling represented the greatest threat to North Atlantic right whales, reducing the North Atlantic right whale population to about 396 in the western North Atlantic Ocean. Whaling was ultimately responsible for their listing as an endangered species. Of the current threats to North Atlantic right whales, entanglement in commercial fishing gear and ship strikes currently pose the greatest threat to North Atlantic right whales. Along the Atlantic Coast of the U.S. and the Maritime Provinces of Canada, there were 33 confirmed reports of right whales being entangled in fishing gear between 2006 and 2010 (Henry et al. 2012). Of these, right whales were injured in five of the entanglements and killed in four entanglements. In the same region, there were 13 confirmed reports of right whales being struck by vessels between 2006 and 2010 (Henry et al. 2012). Right whales were injured in one of the ship strikes and killed in five ship strikes during this same period.

Critical habitat has been designated for the North Atlantic right whale in Cape Cod Bay and the Great South Channel off Massachusetts, and off Georgia and Florida (50 CFR 226.203). In addition, a Mid-Atlantic U.S. Seasonal Management Area (SMA) has been set up within a 20 nm (37 km) radius of the Port of New York and New Jersey (40º29'42.2"N 073º55'57.6"W) from November 1 through April 30 to comply with NOAA's Ship Strike Reduction Rule (50 CFR 224.105). In this designated “Migratory Route and Calving Ground” area, vessels greater than or equal to 65 ft (19.8 m) in overall length must reduce speeds to 10 knots or less in order to avoid vessel strikes to North Atlantic right whales.

North Atlantic right whales transiting the area <u>could occur</u> (rarely) in the Project area (Mainline) and restrictions are in place to protect them (see SMA in Figure 4-1).

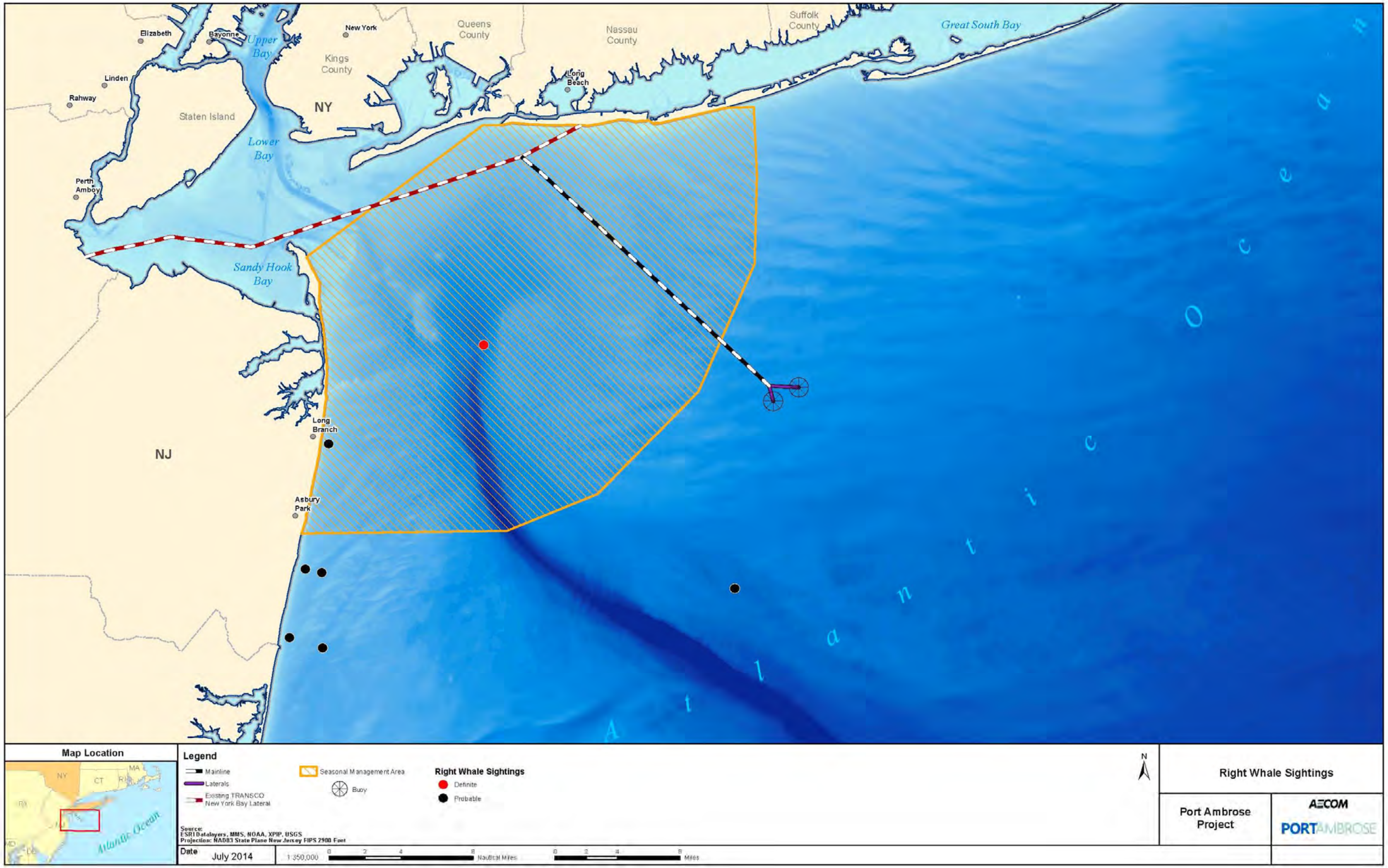
4.1.1.5 Sei whale (*Balaenoptera borealis*) – Endangered

Sei whales occur in every ocean except the Arctic Ocean. The migratory pattern of this species is thought to encompass long distances from high-latitude feeding areas in summer to low-latitude breeding areas in winter; however, the location of winter areas remains largely unknown (Perry et al. 1999). Sei whales are often associated with deeper waters and areas along the continental shelf edge (Hain et al. 1985); however, this general offshore pattern of Sei whale distribution is disrupted during occasional incursions into more shallow and inshore waters (Waring et al. 2004). In the western Atlantic Ocean, Sei whales occur as far North as Labrador, Nova Scotia, in the summer months and migrate south to Florida and the northern Caribbean in winter months (Gambell 1985, Mead 1977).

The 2004 abundance estimate of 386 is considered the best available for the Nova Scotia stock of Sei whales (Waring et al. 2012). There have been no direct estimates of Sei whale abundance in the entire North Pacific based on sighting surveys, but two abundance estimates based on recent line transect surveys of California, Oregon, and Washington waters are 74 (CV=0.88) and 215 (CV=0.71) Sei whales, respectively (Forney 2007, Barlow 2010).

There is a limited amount of information on the vocal behavior of Sei whales and their hearing. McDonald et al. (2005) recorded Sei whale vocalizations off the Antarctic Peninsula that included broadband sounds in the 100- 600 Hz range. Vocalizations from the North Atlantic population consisted of paired sequences of 10-20 short sweeps between 1.5-3.5 kHz (Richardson et al. 1995).

Figure 4-1 Proposed Port Ambrose Project in relation to the North Atlantic right whale SMA and historical sightings



Historically, whaling represented the greatest threat to Sei whales and was ultimately responsible for listing them as an endangered species. Sei whales are occasionally killed in collisions with vessels. Of three Sei whales that stranded along the Atlantic Coast of the U.S. between 1975 and 1996, two showed evidence of collisions with ships (Laist et al. 2001). Between 1999 and 2010, there were six reports of Sei whales being struck by vessels along the Atlantic Coast of the U.S. and the Maritime Provinces of Canada (Cole et al. 2005, Nelson et al. 2007, Henry et al. 2012). Five of these ship strikes were reported as having resulted in the death of the Sei whale. Sei whales are occasionally found entangled. Along the Atlantic Coast of the U.S. and the Maritime Provinces of Canada, there were three confirmed reports of Sei whales being entangled in fishing gear between 2006 and 2010, of which one died (Henry et al. 2012).

Sei whales are <u>not expected (very unlikely)</u> to occur in the Project area, because although they could transit the Project area during migrations in the fall and spring, their presence is very unlikely this close to shore in this region.

4.1.1.6 Sperm whale (*Physeter macrocephalus*) – Endangered

Sperm whales occur in every ocean except the Arctic Ocean. The distribution of the sperm whale in the U.S. Exclusive Economic Zone (EZZ) occurs on the continental shelf edge, over the continental slope, and into mid-ocean regions (Waring et al. 1993, Waring et al. 2001). In the western Atlantic Ocean, sperm whales are concentrated east-northeast of Cape Hatteras in winter, shifting northward in the spring and are found throughout the Mid-Atlantic Bight. Distribution extends further north to areas north of Georges Bank and the Northeast Channel region in summer, and then south of New England in fall, back to the Mid-Atlantic Bight.

Sperm whales have a strong preference for the 3,280 feet (1,000 meters) depth contour and seaward (Reeves and Whitehead 1997). While deep water is their typical habitat, sperm whales have been observed near Long Island, New York, in water between 41-55 meters (135-180 ft) (Scott and Sadove 1997). When they are found closer to shore, they are usually associated with sharp increases in bottom depths where upwelling occurs and biological production is high (Clarke 1956).

Whitehead (2002) estimated that prior to whaling sperm whales numbered around 1,110,000 and that the current global abundance of sperm whales is around 360,000 (coefficient of variation = 0.36) whales. Waring et al. (2007) concluded that the best estimate of the number of sperm whales along the Atlantic coast of the U.S. was 4,804 in 2004, with a minimum estimate of 3,539 sperm whales in the western North Atlantic Ocean.

Sperm whales produce loud broad-band clicks from about 0.1 to 20 kHz (Weilgart and Whitehead 1993, 1997, Goold and Jones 1995). Data from neonatal sperm whales respond to sounds from 2.5-60 kHz. Sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins and Schevill 1975, Watkins et al. 1985).

Three human activities are known to threaten sperm whales: whaling, entanglement in fishing gear, and shipping. Historically, whaling represented the greatest threat to every population of sperm whales and was ultimately responsible for listing sperm whales as an endangered species. Several sperm whale entanglements have been documented in the North Atlantic and three sperm whales have been documented to have been killed by ship strikes (NOAA 2013).

Sperm whales are <u>not expected (unlikely) to occur</u> in the Project area due to their preference for deeper water. Though evidence suggests transients in the area are possible during migrations in the fall and spring, it is unlikely due to their rare occurrence close to shore.

4.1.2 West Indian manatee (*Trichechus manatus*) – Endangered

The West Indian manatee (*Trichechus manatus*) is listed as an endangered species by the USFWS. It is found in freshwater, brackish and marine habitats when they shelter in and/or near warm-water springs, heated industrial effluents, and other warm water sites, usually along the coast (Lefebvre et al. 2001). In the U.S. the distribution is mainly limited to peninsular Florida during the winter, but manatees expand their range and can disperse great distances during the summer months and have been seen as far north as Massachusetts and as far west as Texas (Rathbun et al. 1990, USFWS 2001).

Because of their preference for warmer waters and rare occurrence in the N.Y. Bight and surrounding area, the species is <u>not expected (highly unlikely) to occur</u> in or around the Project area.

4.1.3 Marine mammals protected under the MMPA documented in the northwestern Atlantic Ocean

Twenty-four non-listed (neither listed as threatened or endangered under the ESA) mammal species protected by the MMPA are considered likely to be present in the western North Atlantic Ocean and region for all or part of the year. Some of these species are mainly found either north or south of the Project area, but could be transient through the Project area. These species are as follows:

4.1.3.1 Minke whale (*Balaenoptera acutorostrata*)

The minke whale is a baleen whale with a worldwide distribution. Minke whales are more likely than other baleen whales to approach close to shore and can be found in bays and estuaries. Minke whales are highly migratory and move to cold temperate and polar waters in spring, returning to warmer waters in autumn. They are widely distributed within the U.S. Atlantic EEZ, although primarily north of the Project area, off the coast of New England (Waring et al. 2007). They feed opportunistically on crustaceans (e.g., krill), plankton (e.g., copepods), and small schooling fish (e.g., anchovies, dogfish, capelin, coal fish, cod, eels, herring, mackerel, salmon, sandlance, saury, and wolffish) (NOAA/NMFS 2012b).The best estimate for the Canadian east coast stock is 20,741 (Waring et al. 2013).

The minke whale is <u>not expected (unlikely) to occur</u> in the Project area due to its preference for continental shelf waters and waters further north. If an individual did transit the Project area it is more likely to occur in spring and fall than other months at this latitude.

4.1.3.2 Pygmy Sperm whale (*Kogia breviceps*)

Pygmy sperm whales may be found in all temperate, subtropical, and tropical waters seaward of the continental shelf edge and the slope (Waring et al. 2007, NOAA/NMFS 2008a). They are not believed to migrate. Primary food sources include octopus and squid, but the whales also eat crab, fish, and shrimp (ACS 2008). At sea, it is difficult to distinguish dwarf from pygmy sperm whales, so counts are often grouped together as "*Kogia* spp." The best estimate for the current western North Atlantic population of pygmy sperm whale is 741 (Waring et al. 2013).

Pygmy sperm whales are <u>not expected (unlikely) to occur</u> in the Project area due to their preference for continental shelf edge and slope waters.

4.1.3.3 Dwarf sperm whale (*Kogia sima*)

Dwarf sperm whales are distributed worldwide in temperate to tropical waters along the continental shelf edge and slope (Waring et al. 2007, NOAA/NMFS 2008b).Their primary food sources are cephalopods (e.g., squid and octopus), crustaceans (e.g., shrimp and crabs), and fish (NOAA/NMFS 2008a). The best estimate for the current western North Atlantic population of dwarf sperm whale is 1,042 (Waring et al. 2013).

Dwarf sperm whales are <u>not expected (unlikely) to occur</u> in the Project area due to their preference for continental shelf edge and slope waters.

4.1.3.4 Long-finned pilot whale (*Globicephala melas*)

In the western Atlantic Ocean, the long-finned pilot whale is found from Canada to Cape Hatteras. These whales are found along the continental shelf edge and continental slope in deep pelagic waters off the Northeast United States coast in winter and early spring and migrate onto Georges Bank, into the Gulf of Maine, and into more northern waters in late spring. They tend to occupy areas of high relief or submerged banks (Waring et al. 2011). Most feeding occurs in deep waters (>656 feet [>200 m]) on prey such as fish (e.g., cod, dogfish, hake, herring, mackerel, and turbot), cephalopods (e.g., squid and octopus), and crustaceans (e.g., shrimp) (NOAA/NMFS 2008a). The long-finned pilot whale and the short-finned pilot whale are the only two species of pilot whales commonly found in the western Atlantic, and it is difficult to differentiate these two species at sea. There are an estimated 15,728 individuals from genus *Globicephala* in the area from Maryland to the Bay of Fundy (Waring et al. 2011). The best estimate for the current western North Atlantic population of long-finned pilot whale is 12,619 individuals (Waring et al. 2013).

Due to the long-finned pilot whales' preference for deeper water, this species is <u>not expected (unlikely) to occur</u> in the Project area.

4.1.3.5 Cuvier's beaked whale (*Ziphius cavirostris*)

The distribution of Cuvier's beaked whales is not well understood but appears, based on strandings records, to include the North Atlantic coast from Nova Scotia to Florida, as well as further south into the Caribbean. Most sightings of the species have occurred in the mid-Atlantic region along the continental shelf edge in late spring or summer (Waring et al. 2007). They prefer deeper pelagic waters (>0.5 mi [>1,000 m] deep), as well as steep underwater geologic features. They opportunistically feed on cephalopods (e.g., squid and octopus) and sometimes fish and crustaceans (NOAA/NMFS 2008a). The best estimate for the current western North Atlantic population of Cuvier's beaked whale is 4,962 individuals (Waring et al. 2013).

Due to their preference for deeper water, Cuvier's beaked whales are <u>not expected (unlikely) to occur</u> in the Project area.

4.1.3.6 Mesoplodon beaked whale complex (*Mesoplodon* spp.)

There are four species of beaked whales within the genus Mesoplodon that reside in the northwest Atlantic. They include True's beaked whale (*Mesoplodon mirus*), Gervais' beaked whale (*M. europaeus*), Blainville's beaked whale (*M.densirostris*), and Sowerby's beaked whale (*M. bidens*). These species are difficult to differentiate during field observations; so much of what is known about their distribution is at the genus level (Waring et al. 2007). They feed in deep waters on cephalopods (e.g., squid), mysid shrimp, and small fish (NOAA/NMFS 2008a). Most sightings of the genus have occurred along the continental shelf edge and in deeper waters. Of the Mesoplodon whales, Gervais' whales are the most commonly stranded. Sowerby's whales have the most northern distribution range, from New England north to the ice pack. The best estimate for the current western North Atlantic population of True's and Blainville's beaked whales is unknown, Gervais' beaked whale is 1,847 individuals, and Sowerby's beaked whale is 3,653 individuals (Waring et al. 2013).

Due to their preference for deeper water, species of the genus Mesoplodon are <u>not expected (unlikely) to occur</u> in the Project area.

4.1.3.7 Killer whale (*Orcinus orca*)

While present in all oceans of the world, killer whales are rare in U.S. waters, and very little is known about their distribution there. Rather than engaging in regular seasonal migration, they seem to follow food sources. They prefer colder waters and are one of the few species of whales that move freely from hemisphere to hemisphere. They are opportunistic feeders that prey on other marine mammals (sea lions, seals, porpoises, whales), sharks, penguins, squid, and fish (NOAA/NMFS 2008a). The current western North Atlantic population estimate for the killer whale is unknown (Waring et al. 2013).

Killer whales are <u>not expected (highly unlikely) to occur</u> in the Project area.

4.1.3.8 Pygmy killer whale (*Feresa attenuate*)

Pygmy killer whales are small members of the dolphin family found in deep tropical and subtropical areas around the world. They are present in the Northwest Atlantic, and individuals there are designated as a separate stock; however, only one sighting has been made in the Northwest Atlantic, and population estimates are not available (NOAA/NMFS 2008a; Waring et al. 2007, Waring et al. 2013).

Due to its rarity in the western North Atlantic, this species is <u>not expected (highly unlikely) to occur</u> in the Project area.

4.1.3.9 False killer whale (*Pseudorca crassidens*)

False killer whales, large members of the dolphin family, prefer deep (>0.5 mi [>1,000 m]), tropical to temperate waters. Along the eastern seaboard of the United States, they are found from the mid-Atlantic southward; however, population estimates for this area are not available (NOAA/NMFS 2008a, Waring et al. 2007, Waring et al. 2013). They feed on fishes and cephalopods (NOAA/NMFS 2008a).

Due to their preference for deeper water, this species is <u>not expected (unlikely) to occur</u> in the Project area.

4.1.3.10 Melon-headed whale (*Peponocephala electra*)

Melon-headed whales inhabit deep tropical waters throughout the world. Their main food sources include squid, fishes, and some crustaceans in moderately deep water. Although there is a designated western North Atlantic stock, only two sightings have been made in this region, and population estimates are not available (NOAA/NMFS 2008a; Waring et al. 2007, Waring et al. 2013).

Due to its rarity in the western North Atlantic and preference for deeper and warmer waters, this species is <u>not expected (highly unlikely) to occur</u> in the Project area.

4.1.3.11 Risso’s dolphin (*Grampus griseus*)

Risso’s dolphins inhabit tropical and temperate seas worldwide. In the western Atlantic, they occur from Florida to eastern Newfoundland (Waring et al. 2011). They are found in deep waters (>0.5 mi [>1,000 m] deep) seaward of the continental shelf and slope (NOAA/NMFS 2008a). Their primary food source is squid, but they eat numerous fish species as well (ACS 2008). The population occupies the mid-Atlantic continental shelf edge and slope year round. There are an estimated 15,197 individuals of Risso’s dolphins in the western North Atlantic population (Waring et al. 2013).

Due to its preference for deeper water, Risso’s dophins are <u>not expected (unlikely) to occur</u> in the Project area.

4.1.3.12 Bottlenose dolphin (*Tursiops truncatus*)

Bottlenose dolphins are found in temperate and tropical waters throughout the world. There are two morphotypes that vary in color and size: the coastal morphotype and the offshore morphotype. The distributions of the coastal and offshore morphotypes overlap, but coastal bottlenose dolphins are more likely to migrate into bays, estuaries, and river mouths, while the offshore dolphins tend to reside in deeper waters on the continental shelf (NOAA/NMFS 2008b). Coastal dolphins feed on benthic invertebrates and fish, while the offshore dolphins feed on pelagic squid and fish.

The coastal morphotype of the bottlenose dolphin inhabits the U.S. Atlantic coast from south of Long Island to Florida. Recent analyses of stranding statistics, genetics, photographic identification, and satellite telemetry data suggest that the coastal morphotype can be further subdivided into five coastal stocks, including a Northern Migratory stock which would be in the Project area (Waring et al. 2011). In the northern portion of this range, populations are more likely to be seasonal, migrating to the area in May and staying through October. The best minimum population estimate for the Coastal Northern Migratory stock is 9,604 individuals (Waring et al. 2013). There is also a Western North Atlantic Offshore stock, and the best minimum estimate for the stock is 81,588, though this number may include some sightings from the coastal stock (Waring et al. 2013).

Bottlenose dolphins <u>could occur (likely)</u> in the Project area, especially May through October.

4.1.3.13 Common dolphin (*Delphinus delphis*)

Short-beaked common dolphins are thought to be one of the most widely distributed cetaceans. They are found worldwide in temperate, tropical, and subtropical seas. The population in the western North Atlantic is estimated at 67,191 individuals (Waring et al. 2013). They feed on epipelagic schooling fish and cephalopods (e.g., squid) (NOAA/NMFS 2008a). Short-beaked common dolphins typically occur between the 328 and 6,562-ft (100 and 2,000-m) isobaths on the continental shelf off the coast of the north eastern United States (Waring et al. 2007), and NOAA Fisheries (2012b) depicts them as preferring waters between 650 and 6,500 ft (198 – 1,981 m) deep. Geo-Marine, Inc. (2010), reported sightings of common dolphins off the coast of mid-New Jersey along the 33 to 101-ft (10 to 31-m) isobaths.

Common dolphins <u>could occur</u> (likely) in the Project area, most likely in winter or spring.

4.1.3.14 Striped dolphin (*Stenella coeruleoalba*)

Striped dolphins are distributed in tropical to warm temperate waters worldwide. In the western North Atlantic, they are found from Nova Scotia south to at least Jamaica. Off the coast of the northeast United States, they are located on the continental shelf edge (primarily along the 0.5-mi [1,000-m] depth contour), and in the mid-Atlantic they also can occur over the continental slope and rise (Waring et al. 2007). Their diet is diverse and consists of benthopelagic and pelagic shoaling/schooling fish (e.g., myctophids and cod) and cephalopods (e.g., squid and octopus) (NOAA/NMFS 2008a). The population is estimated to be approximately 46,882 individuals in the western North Atlantic (Waring et al. 2013).

Due to their preference for deeper water on the continental shelf edge, striped dolphins are <u>not expected (unlikely) to occur</u> in the Project area.

4.1.3.15 Clymene dolphin (*Stenella clymene*)

Clymene dolphins are found in deep (820 to 16,404 ft, [250 to 5,000 m]), tropical and sub-tropical waters of the Atlantic (Waring et al. 2007, NOAA/NMFS 2008a). Their U.S. Atlantic distribution range is from New Jersey to Florida. They feed on small mesopelagic fish (e.g., myctophids) and cephalopods (e.g., squid). The size of the western North Atlantic stock is currently unknown (Waring et al. 2013).

Due to their preference for warmer waters, this species is <u>not expected (unlikely) to occur</u> in the Project area.

4.1.3.16 Atlantic spotted dolphin (*Stenella frontalis*)

Atlantic spotted dolphins are found in tropical and warm temperate waters of the western North Atlantic, from southern New England south to Venezuela. Off the northeast U.S. coast, they are found on the continental shelf, along the continental shelf edge, and, south of 40° N, over the deep ocean. At the latitude of the Project area, the species generally is found near the continental shelf edge and slope (Waring et al. 2007). They feed on small fish, benthic invertebrates, and cephalopods (e.g., squid and octopus)

(NOAA/NMFS 2008a). The population size from Maryland to the Bay of Fundy is estimated to be 3,578 (Waring et al. 2007). The best estimate for the Western North Atlantic stock is 26,798 (Waring et al. 2013).

Due to their preference for deeper water along the continental shelf edge, Atlantic spotted dolphins are <u>not expected (unlikely) to occur</u> in the Project area.

4.1.3.17 Spinner dolphin (*Stenella longirostris*)

Spinner dolphins occur in oceanic and coastal tropical waters worldwide. Their distribution in the Atlantic is very poorly understood. Sightings off the northeast U.S. coast have occurred exclusively in deep water (waters greater than 1.2 miles from shore and greater than 2,000 meters deep) (Waring et al. 2007). They feed primarily on mid-water fishes and deep-water squid (NOAA/NMFS 2008a). The western North Atlantic population size is currently unknown (Waring et al. 2013).

Due to its preference for deeper water along the continental shelf edge, Atlantic spotted dolphins are <u>not expected (unlikely) to occur</u> in the Project area.

4.1.3.18 Atlantic white-sided dolphin (*Lagenorhynchus acutus*)

Atlantic white-sided dolphins reside in temperate and sub-polar waters of the North Atlantic, from North Carolina to central West Greenland; however, they are concentrated off the coast of New England and northward. They prefer the relatively shallow continental shelf waters to the 328 ft (100 m) depth contour. There are thought to be three stock units for this species: Gulf of Maine, Gulf of St. Lawrence, and Labrador Sea stocks. The Gulf of Maine stock is most common from Hudson Canyon (located at a latitude of approximately 39° N, or the southern tip of New Jersey) to Georges Bank and in the Gulf of Maine and Bay of Fundy. Sightings off the coast of New York occur year-round but at low densities (Waring et al. 2013). They feed on fish (e.g., mackerel, herring, and hake), as well as squid and shrimp (NOAA/NMFS 2008a). The best estimate for population size of the western North Atlantic stock is 48,819 individuals (Waring et al. 2013).

Atlantic white-sided dolphins are <u>not expected (unlikely) to occur</u> in the Project area.

4.1.3.19 White-beaked dolphin (*Lagenorhynchus albirostris*)

The range of the white-beaked dolphin is more northerly than that of the Atlantic white-sided dolphin, extending from southern New England to southern Greenland; however, there have been occasional strandings on the New York coast. White-beaked dolphins prefer water depths less than 556 ft (200 m). They feed primarily on small mesopelagic and schooling fish (e.g., capelin, cod, haddock, hake, herring, and whiting), crustaceans, and cephalopods (e.g., squid and octopus) (NOAA/NMFS 2008a). The best estimate for the Western North Atlantic stock is 2,003 (Waring et al. 2013).

White-beaked dolphins are <u>not expected (unlikely) to occur</u> in the Project area.

4.1.3.20 Harbor porpoise (*Phocoena phocoena*)

Harbor porpoises are found in the United States and Canadian Atlantic waters. In the summer, they are concentrated in the northern Gulf of Maine and southern Bay of Fundy; however, in the fall and spring they are found from New Jersey to Maine, and in the winter they are found from New Jersey to North Carolina, with lower densities in waters from New York to New Brunswick, Canada (Waring et al. 2011). They can be spotted from the coastline to deep waters (greater than 5,906 feet [1,800 m]), but are concentrated on the continental shelf in waters less than 650 feet (less than 200 m). They are commonly found in bays, estuaries, and harbors of Maine. Limited evidence suggests that they prefer depths of approximately 300 ft (92 m). The southern-most population, the Gulf of Maine/Bay of Fundy population, is estimated at 79,833 individuals (Waring et al. 2013).

Harbor porpoises <u>could occur (likely)</u> in the Project area (Port and Mainline), most likely in spring and summer months.

4.1.3.21 Harbor seal (*Phoca vitulina*)

Harbor seals are the most common seals along the U.S. east coast (NOAA/NMFS 2008b) and are the most abundant seal found in New York State (NYSDEC 2012d). They reside in nearshore waters of the Atlantic Ocean above about 30° N. In the United States, they are found along the New England and New York coast and sometimes south to the Carolinas. They live year-round off the coast of eastern Canada and Maine, and they inhabit the more southern end of their range from September through late May (Waring et al. 2011). The New York Bight is a significant wintering area for harbor seals, and they are common in the waters and at several haul-out locations along the beaches of Long Island (NYSDEC 2012, CRESLI 2012). Populations of harbor seals along the southern shore of Long Island have been increasing since the early 2,000s, leading to a number of seal cruises that tour the coast of Long Island. Jamaica Bay Wildlife Refuge and Fire Island National Seashore are identified as two of the best places on Long Island to see harbor seals (NYSDEC 2012). Seasonal seal walks have been hosted by CRESLI at Cupsogue Beach County Park since 2001 (CRESLI 2012).

In the United States, breeding occurs off the coast of Maine, although they have also been reported as far south as New Jersey during breeding season (NJDEP 2006). They use rocks, reefs, beach, and drifting glacial ice as pupping and haul-out sites (NOAA/NMFS 2008b). They haul out on land to rest, increase body heat, give birth, and socially interact (NOAA/NMFS 2008b). The harbor seal population has been increasing over the last several decades and was estimated in 2001 to be approximately 99,340 individuals along the Maine coast (NOAA/NMFS 2008b; Waring et al. 2011). There is no current abundance estimate for harbor seals (Waring et al. 2013), and it is unknown how many seals inhabit waters south of Maine. The harbor seal diet consists of fish, shellfish, and crustaceans (NOAA/NMFS 2008b).

Because the New York Bight is a significant wintering area for harbor seals and they are common in nearshore waters, this species <u>could occur (likely)</u> in the Project area, especially September through May.

4.1.3.22 Gray seal (*Halichoerus grypus grypus*)

Distribution of gray seals in the western North Atlantic ranges from the coastal waters of New England to Labrador. Pupping generally occurs in Maine and northward, but pupping also has been observed in Nantucket Sound (Waring et al. 2007, CRESLI 2012). They haul out on isolated beaches and rocky ledges of islands, and they will also haul out and give birth on shore-fast and pack ice (Read et al. 2008). Breeding and pupping occur between late September and early March. The diet of gray seals includes benthic and demersal prey (fish, cephalopods, and mollusks) in coastal areas, as well as pelagic schooling fish (Read et al. 2008). There is insufficient available data to estimate the U.S. gray seal population size. In eastern Canada, the population estimate is 195,000 individuals (Waring et al. 2007). Although the range of the gray seal historically has been north of the Project area, USFWS (1997) reports that their range more recently has expanded into the New York Bight. Several hundred gray seals were recorded in surveys conducted off eastern Long Island (Waring et al. 2011). Though the U.S. gray seal population numbers are not known, the most recent NOAA stock assessment considers their range from September to May to include coastal areas south to central N.J. (Waring et al. 2013).

Gray seals <u>could occur (rarely)</u> in the Project area from September to May. If they did transit the Project area, it would be in low concentrations because they are generally found in more northern waters.

4.1.3.23 Harp seal (*Pagophilus groenlandicus*)

Harp seals are distributed throughout much of the Atlantic and Arctic Oceans (Waring et al. 2011). They feed on a wide range of crustacean and fish species (Read et al. 2008). In the western Atlantic, they primarily reside off the coast of eastern Canada, spending much of the year in pack ice (Waring et al. 2007; Read et al. 2008). They are highly migratory. Breeding occurs in mid-February to April, after which the seals migrate north to molt and then further north to their Arctic summer feeding grounds. In late September, they migrate south, usually to the Gulf of St. Lawrence or off the coast of Newfoundland; however, they occasionally migrate into U.S. waters. In recent years, the number of sightings and strandings in U.S. waters has increased from Maine to New Jersey. These sightings generally occur in January through May (Waring et al. 2011). The population estimate for the western North Atlantic stock is 6.9 million individuals, the vast majority of which occur in Canadian waters (Waring et al. 2011). Although the range of the harp seal historically has been north of the Project area, the USFWS (1997) reports that their range more recently has expanded into the New York Bight. Harp seals are seen on a regular basis at haul-outs along Long Island (CRESLI 2012b).

Harp seals* could occur *(rarely) in the Project area, though they do prefer more northern waters. Due to increased presence in the NY Bight, it is possible that they could transit the Project area, although very unlikely and at low concentrations.

4.1.3.24 Hooded seal (*Cystophora cristata*)

Hooded seals inhabit waters of the Atlantic and Arctic Oceans. They are thought to feed primarily on fishes and squid (Read et al. 2008). They prefer deeper waters and generally are found farther offshore than the harp seal (Waring et al. 2007). They whelp in March on pack ice off the coast of eastern Canada (Waring et al. 2007, Read et al. 2008). They live on the edge of pack ice throughout most of the year, following it north in the summer and south in the fall (Read et al. 2008). Hooded seals are highly migratory and occasionally are spotted as far south as Puerto Rico (Waring et al. 2007). Sightings from Maine to Florida are increasing in occurrence, with New England sightings occurring January through May and southeastern U.S. sightings occurring in summer and fall. Their population size for the western North Atlantic is estimated at 592,100 individuals (Waring et al. 2007). The current population estimate for the western north Atlantic is unknown (Waring et al. 2013). Although the range of the hooded seal historically has been north of the Project area, the USFWS (1997) reports that their range more recently has expanded into the New York Bight. Rare sightings of single hooded seals were recorded in 2008 and 2009 on Long Island (Cupsogue Beach) (CRESLI 2012b).

Given their preference for deep waters and rare occurrence near the Project area, hooded seals are not expected (unlikely) to occur in the Project area.

4.2 Sea turtles

Five species of sea turtles occur in the New York Bight (USFWS 1997) in the warmer months, beginning in May with the highest concentrations occurring from June to October (Table 4-2). All five species are listed as threatened or endangered under the ESA; the listed species are:

- Loggerhead sea turtle (*Caretta caretta*)
- Kemp’s ridley sea turtle (*Lepidochelys kempi*)
- Green sea turtle (*Chelonia mydas*)
- Leatherback sea turtle (*Dermochelys coriacea*)
- Hawksbill sea turtle (*Eretmochelys imbricata*)

According to a letter dated August 12, 2013 by NOAA, provided in Appendix A, four of these species have the potential to transit the Project area. Presence of leatherback sea turtles, Kemp's ridley sea turtles, loggerhead sea turtles and green sea turtles are likely in the NY Bight in summer months, beginning in May with the highest concentrations occurring in the June to October period. Hawksbill sea turtles, due to their preference for warmer waters, would be unlikely to transit the Project area. The NY Bight is an important development habitat for the Kemp's ridley turtle and is a key feeding area for leatherback, green, and loggerhead sea turtles (USFWS 1997). Most turtles found in the area are juveniles, typically three to six years of age (USACE 2012).

Effective August 11, 2014, NOAA-NMFS designated critical habitat for the Northwest Atlantic Ocean distinct population segment (DPS) of loggerhead sea turtles. Critical habitat includes a combination of nearshore reproductive habitat, wintering areas, breeding areas, migratory corridors, and Sargassum habitat stretching from Mississippi to the Florida Keys and north along the Atlantic coast to North Carolina. A total of 38 marine areas and 685 miles of shoreline (1,102 km) are designated as critical habitat (Final Rule 78 FR 39855 for marine areas and Final Rule 78 FR 39755 for coastal areas). In February 2010, the Department of Interior (DOI) and Department of Commerce were jointly petitioned to designate critical habitat for Kemp's ridley sea turtle's nesting habitat along beaches of the Texas coast and for marine habitats in the GoM and Atlantic Ocean. NMFS initiated its 5-year status review of the species in 2012 and the petition to designate critical habitat is still under review.

Table 4-2 Sea turtles documented to occur in the northwestern Atlantic Ocean and their expected occurrence in the Project Area

Common Name	Scientific Name	ESA Status	New York Bight Status	Expected Occurrence in Project Area
Loggerhead sea turtle	*Caretta caretta*	Threatened	A, S	**Possible occurrence (likely)** in the Port or Mainline area in summer months.
Kemp's ridley sea turtle	*Lepidochelys kempii*	Endangered	A, S	**Possible occurrence (likely)** in the Port or Mainline area in summer months.
Green sea turtle	*Chelonia mydas*	Threatened	C, S	**Possible occurrence (rare)** in the Port or Mainline area in summer months.
Leatherback sea turtle	*Dermochelys coriacea*	Endangered	A, S	**Possible occurence (likely)** in the Port or Mainline area in summer months.
Hawksbill sea turtle	*Eretmochelys imbricata*	Endangered	R	**Not expected to occur (highly unlikely).** Presence unlikely due to preference for warmer waters.

Sources:
USFWS and NMFS 1993
USFWS 1997
Neubert and Sullivan 2014
Notes:
A=Abundant, C=Common, R=Rare, S=Seasonal

4.2.1 Loggerhead sea turtle (*Caretta caretta*) – Threatened

Loggerhead sea turtles are globally distributed, occurring in temperate and tropical regions of the Atlantic, Pacific, and Indian Oceans (Dodd 1988). The majority of loggerhead nesting is in the Atlantic and Indian Oceans with two nesting aggregations with greater than 10,000 females nesting per year. One of these aggregations is in Florida and the other is in Oman (Baldwin et al. 2003, Ehrhart et al. 2003, Kamezaki et al. 2003, Limpus and Limpus 2003b, Margaritoulis et al. 2003).

Adult loggerheads are known to make considerable migrations from nesting beaches to foraging grounds. Loggerhead turtles travel to northern waters during spring and summer as water temperatures warm, and southward and offshore toward warmer waters in fall and winter. In the western Atlantic, waters as far north as 42^{o} N latitude are foraging habitats for juveniles and adults (Shoop 1987; Shoop and Kenney 1992; Ehrhart et al. 2003; Mitchell et al. 2003). In U.S. Atlantic waters, loggerheads commonly occur throughout the inner continental shelf from Florida to Cape Cod, Massachusetts (Braun-McNeill et al. 2008; Mitchell et al. 2003). Loggerheads have been observed in waters with surface temperatures of 7^{o}C to 30^{o}C, but water temperatures above11^{o}C are considered most favorable (Shoop and Kenney 1992; Epperly et al. 1995b). The presence of loggerhead sea turtles is also influenced by water depth. Aerial surveys of continental shelf waters north of Cape Hatteras, North Carolina indicated that loggerhead sea turtles were most commonly sighted in waters with bottom depths ranging from 22-49 m deep (Shoop and Kenney 1992). However, more recent survey and satellite tracking data support the theory that they occur in waters from the coast to beyond the continental shelf (Mitchell et al. 2003; Braun-McNeill and Epperly 2004; Mansfield 2006; Blumenthal et al. 2006; Hawkes et al. 2006, 2011; McClellan and Read 2007; Mansfield et al. 2009).

Pelagic and benthic juveniles are omnivorous and forage on crabs, mollusks, jellyfish, and vegetation at or near the surface (Dodd 1988; NMFS and USFWS 2008). Sub-adult and adult loggerheads prey on benthic invertebrates such as mollusks and crustaceans in hard bottom habitats (NMFS and USFWS 2008).

In coastal and marine waters, loggerhead turtles can be affected by the following anthropogenic stressors: discharge of pollutants; underwater explosions; dredging, offshore artificial lighting and noise; entrainment or impingement in power plants; entanglement or ingestion of marine debris; vessel traffic and strikes; poaching, interactions with commercial fisheries; and recreational boating and diving (NOAA 2013). Of these potential impacts, interactions with fisheries represent the greatest potential impact because of the number of individuals that are captured and killed in fishing gear each year (Finkbeiner et al. 2011). As with Kemp’s ridley sea turtles, shrimp trawl fisheries account for the highest number of loggerhead sea turtles that are captured and killed, but they are also captured and killed in trawls, traps and pots, longlines, and dredges along the Atlantic coast of the U.S. In 2002, NMFS estimated that almost 163,000 loggerhead sea turtles are captured in shrimp trawl fisheries each year in the Gulf of Mexico, with 3,948 of those sea turtles dying as a result of their capture. Each year, several hundred loggerhead sea turtles are also captured in herring fisheries; mackerel, squid, and butterfish fisheries; monkfish fisheries; pound net fisheries, summer flounder and scup fisheries; Atlantic pelagic longline fisheries; and gillnet fisheries. Although most of these turtles are released alive, these fisheries capture about 2,000 loggerhead sea turtles each year, killing almost 700; and the effects of capture-related stress on the current or expected future reproductive success of sea turtles remains unknown.

In addition to the impacts offshore, a wide variety of anthropogenic activities are thought to adversely affect hatchlings and adult female turtles and their nesting habitats including the following: coastal development; placement of erosion control structures and other barriers to nesting; beachfront lighting; vehicular and pedestrian traffic; beach sand extraction and placement; coastal pollution; removal of native vegetation; poaching; and predation (NMFS and FWS 1998, 2008; Margaritoulis et al. 2003; NOAA 2013).

Loggerhead sea turtles could occur (likely) in the Project area in summer months.

4.2.2 Kemp’s ridley sea turtle (*Lepidochelys kempii*) – Endangered

The Kemp's ridley sea turtle is found from the Gulf of Mexico and along the Atlantic coast of the U.S. (NMFS et al. 2011), as far north as the Grand Banks (Watson et al. 2004) and Nova Scotia (Bleakney 1955); and East to the Azores and eastern north Atlantic and Mediterranean of the species (Tomas and Raga 2008; Insacco and Spadola 2010). Although females rarely leave the Gulf of Mexico and adult males do not migrate, juveniles feed along the east coast of the United States up to the waters off Cape Cod, Massachusetts (Spotila 2004). Because of this migration, juvenile Kemp's ridley sea turtles are the second most abundant sea turtle found in the mid-Atlantic region from New England, New York, and the Chesapeake Bay, south to coastal areas off North Carolina (Morreale et al. 2007; TEWG 2000; Schmid 1998; Wibbels et al. 2005). In the fall, the juvenile turtles migrate south along the coast, forming one of the densest concentrations of Kemp's ridley sea turtles outside of the Gulf of Mexico (Musick and Limpus 1997).

The Kemp's ridley sea turtle prefers nearshore temperate waters shallower than 50 meters (NMFS and USFWS 2007c), although it is not uncommon for adults to be found in deeper waters (Byles 1989a; Mysing and Vanselous 1989; Renaud et al. 1996; Shaver et al. 2005; Shaver and Wibbels 2007b). Foraging areas have been documented along the U.S. Atlantic coast including in the shallower waters of the Long Island Sound (Morreale and Standora 1993; Morreale et al. 2005).

The majority of Kemp's ridley sea turtles nest along a single stretch of beach near Rancho Nuevo, Tamaulipas, Mexico (Carr 1963; NMFS and USFWS 2007c; NMFS et al. 2011). The number of recorded nests reached an estimated low of 702 nests in 1985, corresponding to fewer than 300 adult females nesting (TEWG 2000; NMFS and USFWS 2007c; NMFS et al. 2011). Conservation efforts since that time by Mexican and U.S. agencies eliminated egg harvest, protected eggs and hatchlings, and reduced at-sea mortality through fishing regulations (TEWG 2000). Since the mid-1980s, the number of nests observed at Rancho Nuevo and nearby beaches has increased 14%-16% per year (Heppell et al. 2005). An estimated 5,500 females nested in Tamaulipas, Mexico over a three-day period in May 2007 with more than 4,000 of those nesting at Rancho Nuevo (NMFS and USFWS 2007c). In 2008, 17,882 nests were documented on Mexican nesting beaches (NMFS 2011b).

Like other sea turtle species, the Kemp's ridley population has been influenced by a combination of exploitation of eggs, impacts from fishery interactions, loss of foraging habitat, and marine pollution. From the 1940s through the early1960s, nests from Rancho Nuevo were heavily exploited, but beach protection in 1967 helped to curtail this activity (NMFS et al. 2011).

Kemp's ridley sea turtles have been captured and killed by fishing gear throughout their range. They have been captured in gear used in lobster fisheries and monkfish fisheries off the northeastern United States, pound net fisheries off eastern Long Island, the mid-Atlantic and Chesapeake Bay; fisheries for squid, mackerel, butterfish, bluefish, summer flounder, Atlantic herring, weakfish, and the sargassum (NOAA 2013). The most significant fishery-related threat to Kemp's ridley sea turtles has been the number of sea turtles that have been captured and killed in the shrimp trawl fisheries in the Gulf of Mexico, although modifications to shrimp trawls have helped to reduce mortality of Kemp's ridleys sea turtles (NOAA 2013). Finkbeiner et al. (2011) compiled cumulative bycatch information in U.S. fisheries from 1990 through 2007. In the Atlantic, a mean estimate of 137,700 bycatch interactions, of which 4,500 were mortalities, occurred annually (since implementation of bycatch mitigation measures).

Other impacts to the species have also been observed. For example, impingement/intake mortalities were documented at a nuclear power plant in NJ from 1992-2006 (NMFS 2006b), and the impacts of coastal dredging remains a concern (NOAA 2013). NMFS' biological opinions in the recent past have required non-dredging "windows" to protect nesting females as well as relocation trawls that precede dredging equipment to relocate turtles out of the dredge path (NOAA 2013).

Juvenile Kemp's ridley sea turtles could occur (likely) in the Project area in warmer months when they migrate north.

4.2.3 Green sea turtle (*Chelonia mydas*) – Threatened

Green sea turtles are distributed worldwide, and can be found in the Pacific, Indian, and Atlantic Oceans, primarily in tropical or subtropical waters (NMFS and USFWS 1991 and 2007d). Because green turtles appear to prefer waters that are above 18- 20^{o}C they are not normally found in the Project area in winter. In warmer summer months, in the western Atlantic, juvenile and adult green sea turtles occur seasonally along the Eastern U.S. coast and can be found as far North as Massachusetts (Wynne and Schwartz 1999), and as such, have been documented in the Long Island Sound (Musick and Limpus 1997; Morreale and Standora 1998; Morreale et al. 2005).

Historically, the primary cause of the global decline of green sea turtles populations was the number of eggs and adults captured and killed on nesting beaches and in coastal areas. Even today, some populations of green sea turtles are harvested by subsistence hunters or illegally by poachers. Green sea turtles were once directly harvested in U.S. fisheries, but that is no longer the case.

Another main cause of green sea turtle mortality is from incidental death due to fisheries entanglement. Other activities like channel dredging, marine debris, aquatic pollution, vessel strikes, power plant impingement, and habitat destruction account for additional mortalities, though these numbers have not been quantified (NOAA 2013). Stranding reports indicate that between 200-400 green sea turtles strand annually along the eastern U.S. coast from a variety of causes, most of which are unknown (STSSN database).

Conservative estimates are that green turtle populations have declined by 34% to 58% during the last 150 years (Seminoff 2002), though actual declines may be as high as 70% or 80% (NOAA 2013). Causes for these declines include continued harvest of eggs, sub-adults and adults in some countries, incidental take by fisheries, loss of habitat, and disease. While some nesting populations of green turtles appear to be stable or increasing in the Atlantic Ocean, declines of over 50% have been documented in the eastern and western Atlantic (NOAA 2013).

Green turtles could occur (rare) in the Project area in summer months when waters are above 18 or 20^{o}C.

4.2.4 Leatherback sea turtle (*Dermochelys coriacea*) – Endangered

Leatherback sea turtles are widely distributed throughout the oceans of the world, including the Atlantic, Pacific, and Indian Oceans (Casale et al. 2003; Ernst and Barbour 1972; Hamann et al. 2006b). Leatherback sea turtles have evolved physiological and anatomical adaptations that allow them to exploit colder waters (Frair et al. 1972; Greer et al. 1973; NMFS and USFWS 1995); and so their Northern Atlantic range includes areas as far north as the North and Barents Seas and Newfoundland and Labrador (Goff and Lien 1988; Hughes et al. 1998; Luschi et al. 2003; Luschi et al. 2006; Márquez 1990; Threlfall 1978).

Leatherback sea turtles are highly migratory, exploiting convergence zones and upwelling areas in the open ocean and along continental margins (Morreale et al. 1994; Eckert 1998; Eckert 1999). In the North Atlantic Ocean leatherback turtles occur regularly in deep waters, and in a single year, can swim more than 6,000 miles (10,000 kilometers) (Eckert 1998). An aerial survey in the North Atlantic observed leatherback turtles in continental shelf and pelagic environments in offshore waters ranging from 7-27^{o} C (Cetacean and Turtle Assessment Program [CeTAP] 1982), though juveniles prefer warmer and more tropical waters with temperatures above 21^{o} C (Eckert 2002).

Leatherback turtles are predominately pelagic, foraging widely in temperate waters except during nesting season, when females return to tropical beaches to lay eggs. Males are rarely observed near nesting areas, and it is thought that leatherback sea turtles mate outside of tropical waters, before females swim to their nesting beaches (Eckert and Eckert 1988). Based on genetic studies, Atlantic Ocean leatherbacks are currently being divided into seven breeding populations (Turtle Expert Working Group [TEWG] 2007).

Globally, leatherback turtle populations have declined worldwide and many local populations are in danger of extinction (NMFS 2001b; NMFS 2001a). Increases in the number of nesting females have been noted at some sites along coasts of the Atlantic Ocean, but these increases are far outweighed by declines in other parts of the world. Spotila et al. (2004b) estimated the global population of female leatherback turtles to be

35,860 individuals (confidence limits: 26,200 to 42,900), and recent data suggests that the Western Atlantic populations declined from 18,800 nesting females in 1996 (Spotila et al. 1996) to 15,000 nesting females by 2000 (NMFS 2001).

The greatest anthropogenic threats to leatherback sea turtles are from entanglement in fishing gear (e.g., gillnets, longlines, lobster pots), direct harvest of adults, sub-adults and eggs, the degradation of nesting and coastal habitats, vessel collisions, impacts of underwater sound, and ingestion of marine debris (NMFS and USFWS 2007, TEWG 2007). Other possible causes of decline include: domesticated animal predation; artificial lighting on beaches that disorients adult female and hatchling sea turtles; beach replenishment activities that destroy habitat; and possibly environmental contaminants (NMFS and USFWS 2007).

Leatherback sea turtles are thought to be the most vulnerable species of sea turtles to entanglement in fishing gear (Finkbeiner 2011).This susceptibility could be the result of their body type, diving and foraging behavior, distributional overlap with gear, possible attraction to organisms and algae that collect on buoys and buoy lines, or to the light sticks used to attract target species in longline fisheries (NOAA 2013).

Leatherbacks may be more susceptible to marine debris ingestion than other sea turtle species due to the tendency of floating debris to concentrate in convergence zones that juveniles and adults use for feeding (Shoop and Kenney 1992; Lutcavage et al. 1997). Necropsy results of leatherback sea turtles revealed that a substantial percentage (34% of the 408 leatherback necropsies conducted from 1885 and 2007) reported plastic within the turtle's stomach, and in some cases (8.7%) blockage of the gut was found in a manner that may have caused the mortality (Mrosovsky et al. 2009).

Leatherback sea turtles <u>could occur (likely)</u> in the Project area in summer months.

4.2.5 Hawksbill sea turtle (*Eretmochelys imbricate*) – Endangered

Hawksbill sea turtles are distributed throughout tropical and subtropical waters of the Atlantic, Indian, and Pacific oceans. The species is widely distributed in the Caribbean Sea and western Atlantic Ocean, with individuals from several life history stages occurring regularly along southern Florida and the northern Gulf of Mexico; in the Greater and Lesser Antilles; and along the Central American coast south to Brazil (Amos 1989). Off the east coast of the U.S. hawksbill sea turtles have been reported in stranding data and alive from the waters off Florida to Massachusetts; however, sightings of hawksbill sea turtles north of Florida are rare (Wallace et al. 2010). Within the continental United States, hawksbill sea turtles nest only on beaches along the southeast coast of Florida and in the Florida Keys.

The greatest anthropogenic threats to hawksbill sea turtles are harvest of animals, incidental capture in commercial fisheries, and human development of the coast.

Because of their rare occurrence north of Florida waters, hawksbill sea turtles <u>are not expected (highly unlikely) to occur</u> in the Project area.

4.3 Fish

Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) is the only ESA listed fish species known to be present in the waters of the NY Bight year-round with five distinct population segments (DPSs) listed as endangered or threatened under the ESA. According to NOAA, all four endangered DPSs: (1) New York Bight DPS, (2) Chesapeake Bay DPS, (3) Carolina DPS, and (4) South Atlantic DPS; and one threatened population, Gulf of Maine DPS could occur in the Project area (see Appendix A; NOAA letter dated August 12, 2013). Although Atlantic sturgeon have the potential to transit through the Project area they are not likely to remain in the area due to the lack of foraging habitat near the proposed Project site.

Atlantic sturgeon is a subspecies of sturgeon distributed along the eastern coast of North America from Hamilton Inlet, Labrador, Canada to the Saint Johns River in Florida (Smith and Clugston 1997, Atlantic

Sturgeon Status Review Team [ASSRT] 2007). Historically, Atlantic sturgeon were present in approximately 38 rivers in the United States from St. Croix, ME to the Saint Johns River, FL, of which 35 rivers have been confirmed to have had historic spawning populations. Atlantic sturgeon is currently present in 36 rivers, and spawning occurs in at least 20 of these. Other estuaries along the coast formed by rivers that do not support Atlantic sturgeon spawning populations may still be important rearing habitats.

Atlantic sturgeon are long lived, late maturing, estuarine dependent, anadromous fish. Atlantic sturgeon spawn in freshwater, but spend most of their sub-adult and adult life in the marine environment. Spawning is believed to occur in flowing water between the salt front of estuaries and the fall line of large rivers.

Studies suggest that young-of-year, age-1, and age-2 juvenile Atlantic sturgeon occur in low salinity waters of the natal estuary (Haley 1999; Hatin et al. 2007; McCord et al. 2007; Munro et al. 2007). Atlantic sturgeon remain in the natal estuary for months to years before emigrating to open ocean as subadults (Holland and Yelverton 1973; Dovel and Berggen 1983; Waldman et al. 1996; Dadswell 2006; ASSRT 2007). After emigration from the natal estuary, subadults and adults travel within the marine environment, where they may undergo extensive movements usually confined to shelly or gravelly bottoms in 10-50 m (33-164 ft) water depths (Stein et al. 2004; Erickson et al. 2011). Fish distribution varies seasonally within this depth range. During summer months (May to September) fish are primarily found in the shallower depths of 10-20 m (33-66 ft). In winter and early spring (December to March), fish move to depths between 20 and 50 m (66 and 165 ft) (Erickson et al. 2011). Atlantic sturgeon commonly aggregate in the Connecticut River estuary, Long Island Sound and New York Bight.

The Atlantic sturgeon fishery was closed by the Atlantic States Marine Fisheries Commission in 1998, when a coastwide fishing moratorium was imposed for 20-40 years, or at least until 20 year classes of mature female Atlantic sturgeon were present (Atlantic States Marine Fisheries Commission [ASMFC] 1998).There are no current, published population abundance estimates for any of the currently known spawning stocks. Therefore, there are no published abundance estimates for any of the five DPSs of Atlantic sturgeon. An estimate of 863 mature adults per year (596 males and 267 females) was calculated for the Hudson River based on fishery-dependent data collected from 1985-1995 (Kahnle et al. 2007).

The main anthropogenic threat to Atlantic sturgeon is from mortalities associated with bycatch in fisheries. Other possible threats include ship strikes, channel dredging, dams and poor water quality. Ship strikes have been documented in the Delaware River, James River and Hudson River ecosystems (NOAA 2013). Dredging can affect sturgeon by removing food resources, eliminating high quality habitat, or directly killing fish by the dredging itself. The presence of dams could impact connectivity and impact Atlantic sturgeon spawning and juvenile developmental habitat. Atlantic sturgeon are also sensitive to pesticides, heavy metals, and other toxins in the aquatic environment. More detailed information on threats to Atlantic sturgeon can be found in the status review (Atlantic Sturgeon Status Review Team 2007).

Atlantic Sturgeon <u>could occur (likely)</u> in the Project are, but only as transients.

4.4 Estimated abundance and seasonality of potentially occurring protected species

As outlined above, nine species of marine mammals (three whales, two dolphins, one porpoise, and three seals) could occur in the Project area. Three of these marine mammals are whales that are listed under the ESA as endangered, including the following species: fin whale (*Balaenoptera physalus*), humpback whale (*Megaptera novaeangliae*), and the North Atlantic right whale (*Eubalaena glacialis*). In addition to these ESA-listed species, six additional marine mammals protected under the MMPA have the potential to transit the Project area (Port and Mainline): harbor porpoise (*Phocoena phocoena*), bottlenose dolphin (*Tursiops truncatus*), common dolphin (*Delphinus delphis*), harbour seal (*Phoca vitulina*), gray seal (*Halichoerus grypus*), and harp seal (*Pagophilus groenlandicus*). Leatherback sea turtles, Kemp's ridley sea turtles, loggerhead sea turtles, green sea turtles and the five Atlantic Sturgeon DPSs could also transit the Project area in certain months. Tables 4-3 and 4-4 summarize the potential abundance by season for the nine species of marine mammals, four species of turtles and Atlantic Sturgeon DPSs outlined above that could occur in the Project area (Neubert and Sullivan (2014); based on values presented in Legueux et al. 2010).

Table 4-3 Potential abundance (by season) for marine mammals, sea turtles and Atlantic sturgeon that could potentially occur in the project area during construction and operations

Species	Seasonal Relative Abundance	Port Footprint				Mainline Footprint			
		Spring	Summer	Winter	Fall	Spring	Summer	Winter	Fall
North Atlantic right Whale	rare	0-1.4	0-1.4	0-1.4	0-1.4	0-1.4	0-1.4	0-1.4	0-1.4
Fin Whale	low to very abundant	23-45	23-45	23-45	0-22	23-45	23-45	23-112	0-22
Humpback Whale	rare to common	0-20	0-20	0-20	21-40	0-20	0-20	0-20	21-61
Bottlenose Dolphin	rare to low	0-747	0-747	0-747	0-747	0-747	0-1495	0-747	0-747
Common Dolphin	rare to low	2197-4393	0-2196	2197-4393	0-2196	0-4393	0-2196	0-4393	0-2196
Harbor Porpoise	rare to very abundant	12-16	6-11	0-5	0-5	17-27	0-11	0-5	0-5
Seals	rare to low	1294-2586	0-1293	0-1293	0-1293	1294-2586	0-1293	0-1293	0-1293
Leatherback Turtle	rare to very abundant	0-8	25-32	0-8	9-16	0-8	33-40	0-8	0-16
Loggerhead Turtle	rare to low	0-119	120-237	0-119	120-237	0-119	120-237	0-119	120-237
Kemp's Ridley Turtle	rare to common	0-13.9	0-27.8	0-13.9	0-13.9	0-13.9	14-41.7	0-13.9	0-13.9
Green Turtle	rare	ND	ND	ND	ND	ND	ND	ND	ND
Atlantic Sturgeon	rare	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Abundance estimates are presented as ranges (by season) in Neubert and Sullivan (2014) and are based on values presented in Legueux et al. 2010) ND=No data presented for green turtles in the above reports.									

Table 4-4 Seasonal trends (by month) of the likely occurrence of MMPA protected and/or ESA listed species that could potentially occur (transit) the Project area.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Marine mammals												
North Atlantic right whales	R	R	R	R							R	R
Humpback whales	R	R	R	R	R	R	R	R	✓	✓	✓	R
Fin whales	✓	✓	✓	✓	✓	✓	✓	✓	R	R	R	✓
Bottlenose dolphins					✓	✓	✓	✓	✓	✓		
Common dolphin	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Harbor porpoises	✓	✓	✓	✓	✓	✓				✓	✓	✓
Harbor seals	✓	✓	✓	✓	✓	✓	✓	✓	✓			
Gray seals	✓	✓	✓	✓	✓	✓	✓	✓	✓			
Harp seals	✓	✓	✓	✓	✓	✓	✓	✓	✓			
Sea Turtles												
Kemp's Ridley sea turtle						✓	✓	✓	✓	✓		
Green sea turtle						R	R	R	R	R		
Leatherback sea turtle						✓	✓	✓	✓	✓		
Loggerhead Sea Turtle						✓	✓	✓	✓	✓		
Fish												
Atlantic Sturgeon	R	R	R	R	R	R	R	R	R	R	R	R

Note: R = Rare transient
Sources:
Waring et al. 2013
Neubert and Sullivan 2014

5.0 Noise Exposure Criteria

5.1 Marine mammals

5.1.1 Marine mammals and underwater sound

Marine mammals live in an environment in which vision is not the primary sense because light does not penetrate far beneath the surface of the ocean. As such, marine animals often rely upon sound, instead of sight, as their primary sense for communication and awareness of their environment. Marine mammal communication has a variety of functions such as mother/calf cohesion, group cohesion, individual recognition and danger avoidance.

5.1.2 Hearing sensitivity in marine mammals

Species of cetaceans and pinnipeds were assigned to functional hearing groups based on their hearing characteristics by Southall et al. (2007). Each functional hearing group has been assigned an M-weighting function to account for the fact that marine mammals do not hear equally well at all frequencies within their functional hearing range. M-weighting functions de-emphasize frequencies that are near the lower and upper frequency end of the estimated hearing range, where noise levels have to be higher to result in the same auditory effect (Southall et al. 2007). The M-weighting functions are similar in intent to the C weighting function that is commonly used when assessing the impact of high-amplitude sounds on humans.

NOAA's Draft Guidance suggests revision to the M-weighting functions and functional hearing groups to account for new research findings; both expanding the upper hearing range of low frequency cetaceans, and splitting pinnipeds into two families.

Table 5-1 presents the estimated auditory bandwidth, species relevant to this assessment and the M-weighting function applicable for this functional hearing group.

Table 5-1 Marine mammal functional hearing groups from NOAA Draft Guidance (NOAA 2014)

Functional Hearing Group	Estimated Auditory Bandwidth	Relevant Species to Port Ambrose Project	Functional Hearing Group M-Weighting
Low frequency (LF) cetaceans	7 Hz – 30 kHz	North Atlantic right whale Humpback whale Fin whale	M_{lf}
Mid frequency (MF) cetaceans	150 Hz – 160 kHz	Bottlenose dolphin Common dolphin	M_{mf}
High frequency (HF) cetaceans	200 Hz – 180 kHz	Harbor porpoise	M_{hf}
Phocid pinnipeds (seals)	75 Hz – 100 kHz	Harbor seal Harp seal Gray seal	M_{pp}
Note: Species-specific hearing information for marine mammal species is presented in Section 4 (above).			

Revised cetacean M-weighting functions (M_{lf}, M_{mf}, M_{hf}, and M_{pp}) were developed by NOAA incorporating new research on marine mammal hearing.

The revised M_{lf} function utilizes research from Ketten (1998), Houser et al. (2001), and Tubelli et al. (2012) combining an Equal Loudness Function for LF cetaceans with the previous M-weighing curves from Southall et al. (2007). The resulting M_{lf} frequency weighting function for LF cetaceans is more sensitive to noise at frequencies between approximately 30Hz and 10kHz when compared to the previous M-weighting curve.

The revised M_{mf} and M_{hf} weighting functions use a similar approach, combining Equal Loudness Functions with the previous M-weighting curves from Southall et al. (2007). For MF cetaceans the equal loudness function was derived from measurements of Bottlenose Dolphin by Finneran and Schlundt (2011) and frequency specific TTS data from Finneran and Schlundt (2009); Finneran and Schlundt (2010); and Finneran and Schlundt (2013).

Equal loudness data was not available for HF cetaceans. To develop a revised M_{hf} function, NOAA extrapolated the cut-off frequencies of both the MF cetacean equal loudness function and the previous M-weighting function using an approach based upon octave spacing from ANSI (1994) and frequency perception detailed in Yost (1994) and Ketten (2000).

The M_{pp} weighting function for phocid pinnipeds underwater does not incorporate an equal loudness function curve, as EQL measurements have not been undertaken on any pinniped species. NOAA has extended the upper functional hearing range of the pinniped curve proposed by Southall et al. (2007) to reflect research by Hemilä et al. (2006) and Kastelein et al. (2009). An upper cut-off frequency of 100 kHz (previously 75 kHz) is specified for phocid pinnipeds in the Draft Guidance.

5.1.3 Noise exposure criteria for marine mammals

NOAA's Draft Guidance is anticipated to form the applicable criteria for assessing underwater noise impacts on marine mammals. The Guidance proposes dual criteria, utilizing both dB_{peak} and SEL_c metrics, with assessment to be based upon whichever criterion is exceeded first. Both M-weighted and unweighted SEL criteria are provided; however, NOAA notes that the unweighted SEL criteria are likely to result in an overly conservative assessment, as they do not take into account the hearing sensitivity of the receiver functional hearing group. Table 5-2 outlines the criteria from the Draft Guidance which have been adopted for this assessment.

Table 5-2 Applicable underwater noise criteria for cetaceans (excerpt from Table 6 of NOAA's Draft Guidance)

Hearing Group	PTS Onset (Level A Harassment)		TTS Onset (Level B Harassment)	
	Impulsive	Non-impulsive	Impulsive	Non-impulsive
LF Cetaceans	230 dB_{peak} 187 $dB(M_{lf})$ SEL_c	230 dB_{peak} 198 $dB(M_{lf})$ SEL_c	224 dB_{peak} 172 $dB(M_{lf})$ SEL_c	224 dB_{peak} 178 $dB(M_{lf})$ SEL_c
MF Cetaceans	230 dB_{peak} 187 $dB(M_{mf})$ SEL_c	230 dB_{peak} 198 $dB(M_{mf})$ SEL_c	224 dB_{peak} 172 $dB(M_{mf})$ SEL_c	224 dB_{peak} 178 $dB(M_{mf})$ SEL_c
HF Cetaceans	201 dB_{peak} 161 $dB(M_{hf})$ SEL_c	201 dB_{peak} 180 $dB(M_{hf})$ SEL_c	195 dB_{peak} 146 $dB(M_{hf})$ SEL_c	195 dB_{peak} 160 $dB(M_{hf})$ SEL_c
Phocid Pinnipeds	235 dB_{peak} 192 $dB(M_{pp})$ SEL_c	235 dB_{peak} 197 $dB(M_{pp})$ SEL_c	229 dB_{peak} 177 $dB(M_{pp})$ SEL_c	229 dB_{peak} 183 $dB(M_{pp})$ SEL_c

Notes:

(1) All levels are expressed in linear dBpeak re 1µPa (dBpeak) or M-weighed dB re 1 µPa2s (SELc) applicable at the receiver location.

(2) Noise is to be assessed on the basis of whichever criterion is exceeded first.

5.2 Sea turtles

5.2.1 Hearing in sea turtles

Little is known about how sea turtles make use of sound in both terrestrial and underwater environments. However, as more research emerges on the physiology of turtle auditory systems and the auditory response of turtles, it is suggested that turtles likely use sound for navigation, location of predators/prey, and environmental awareness (Piniak et al. 2012).

Bartol et al. (1999) and Ridgway et al. (1969) suggest that turtle hearing was most sensitive to frequencies below 1,000 Hz when subject to airborne noise. The study by Piniak et al. (2012) agrees with these conclusions for airborne noise, however it concludes that turtles are likely to be able to detect higher frequencies underwater, with tests on juvenile green turtles showing response to stimuli up to 1,600 Hz.

Information on loggerhead turtle hearing is very limited. Bartol et al. (1999) studied the auditory evoked potential of loggerhead sea turtles and concluded that loggerhead sea turtles had the most sensitive hearing between 250 and 1,000 Hz, with rapid decline above 1,000 Hz (Bartol et al. 1999, Lenhardt 1994; Lenhardt et al. 1983; Moein Bartol and Ketten 2006; Moein Bartol et al. 1999; O'Hara and Wilcox 1990).

Information on green turtle hearing is limited. Ridgway et al. (1969) studied the auditory evoked potentials of three green sea turtles and concluded that their maximum sensitivity occurred from 300 to 400 Hz with rapid declines for tones at lower and higher frequencies. In a study of the auditory brainstem responses of subadult green sea turtles, responses to frequencies between 100 and 500 Hz occurred; with highest sensitivity between 200 and 400 Hz (Bartol and Ketten 2006). Currently, the upper hearing limit for green turtles is thought to be between 400 and 1600 Hz in water, with maximum sensitivity occurring between 50 and 400 Hz for juvenile green turtles (Piniak et al. 2012).

There is no information on Kemp’s ridley sea turtle or leatherback sea turtle hearing, however, it is assumed that their hearing sensitivities are similar to those of green and loggerhead sea turtles with their best hearing sensitivity in the low frequency range from 50 to 400 Hz with rapid declines for tones at lower and higher frequencies with an upper limit of about 1,600 Hz in water (Piniak et al. 2012).

5.2.2 Noise exposure criteria for turtles

There are no published underwater noise criteria for turtles in U.S. waters. Young (1991), cited in Keeven & Hempen (1997) provides an empirical safety range equation for underwater explosions from military activities for a variety of marine fauna, including turtles. The safety range was based on Gulf of Mexico oil platform criteria established by the NMFS.

Keeven & Hempen (1997) also provide details of two cases where physical injury was reported in turtles unintentionally exposed to underwater explosions, with details of the charge weight and approximate distance the injured turtle was from the blast. Substituting the values from these cases into the equations from Young (1991) gives an equivalent peak noise safety level for turtles of 222 dBpeak re 1 µPa. We have adopted this level as the harm criterion for turtles (Table 5-3).

Behavioral criterion is derived from McCauley et al. (2000) who conducted tests on Green and Loggerhead Turtles that showed increased swimming behavior when exposed to noise from air guns between levels of 166 – 75 dB_{rms} re 1 µPa (Table 5-3).

Table 5-3 Underwater noise criteria for sea turtles

Hearing group	Non-auditory or auditory injury (Harm)	Behavioral response (Harassment)
Sea turtles	222 dB_{peak}	175 dB_{rms}
Notes: All levels are expressed in linear dB_{peak} re 1µPa or linear dB_{rms} re 1µPa, applicable at the receiver location		

5.3 Fish (Atlantic Sturgeon)

5.3.1 Hearing in fish

An important function of fish hearing is to learn about their surrounding environment, a process referred to as sampling of the 'acoustic scene' in the same manner as other vertebrates (Bregman 1991). Awareness of the acoustic scene allows fish to learn more about their environment than from visual inspection alone because light does not travel far underwater. Besides using sound for understanding their physical environment, fish also use sound to communicate, locate prey, and avoid predators.

Sensitivity to noise and vibration differs among fish species according to the anatomy of the swim bladder and its proximity to the inner ear. Fish species are typically divided into two broad groups—specialists and generalists—based on their different levels of hearing specialization (Hastings and Popper 2005).

Hearing generalists sense acoustic energy directly through their inner ear and also from their swim bladder if present. Hearing specialists have evolved specialized auditory systems which generally include one of a number of different mechanisms to couple the swim bladder or other gas-filled structure (prootic bulla) to the inner ear (Nedwell et al 2004). The swim bladder or gas-filled structure functions as a pressure transducer that re-radiates acoustic energy in the form of particle motion that can be detected by the inner ear. This increases hearing sensitivity in comparison to hearing generalists and generally makes them more susceptible to noise.

Information about the hearing range of Atlantic sturgeon is inferred from studies concerning other species of sturgeon (Meyer and Popper 2003 and 2005). The Bureau of Ocean Energy Management (BOEM) (2012c) categorizes sturgeon, in general, as fishes that detect sounds from below 50 Hz to perhaps 800-1,000 Hz (though several probably only detect sounds to 600-800 Hz). These fish have a swim bladder, but no known structures in the auditory system that would enhance hearing, and their sensitivity (lowest sound detectable at any frequency) is not very great, hence they are considered generalists. Sounds would have to be more intense to be detected compared to fishes with swim bladders that enhance hearing. Sturgeon can detect both particle motion and pressure.

5.3.2 Effects of underwater sound on fish (Atlantic Sturgeon)

Underwater noise effects on fish can include alteration of behavior, damage to auditory and non-auditory tissue, and mortality. The level of impact depends on the intensity and character of the noise, the distance to the noise source, and the size, mass and anatomical characteristics of the fish species (Hastings and Popper 2005).

Damage to the sensory hair cells of the ear and temporary threshold shift (TTS) may be caused by exposure to low noise levels for a prolonged period or high noise levels for a short period. There is some evidence that fish can replace or repair damaged sensory hair cells (ICF Jones and Stokes 2009). It has also been found that fish are able to recover from TTS in less than 18 hours after exposure.

A temporary reduction in hearing sensitivity or damage to auditory tissue can also cause indirect behavioral effects (Hastings and Popper 2005), though these indirect behavioral impacts are poorly understood in most species of fish.

The pressure pulses generated by high energy noise sources, such as blasting and pile driving of large diameter piles, can cause the swim bladder of fish to rupture or tear (Hastings and Popper 2005). This generally only occurs in the immediate vicinity of the source where the pressure rises and reduces quickly to its positive and negative peak pressure level. The sudden increase and decrease in pressure level causes gas oscillations that can rupture or tear the swim bladder.

Other non-auditory tissue damage that has been investigated includes capillary ruptures or eye hemorrhage caused by gas bubbles formed in the blood or eye tissue due to high noise levels, neurotrauma causing loss of consciousness, and in some cases mortality (Hastings and Popper 2005). Generally, smaller fish are more susceptible to non-auditory tissue damage than larger fish.

5.3.3 Noise exposure criteria for fish

There are no published underwater noise criteria for Atlantic sturgeon. As stated above the BOEM (2012c) categorizes sturgeon, in general, as fishes that detect sounds from below 50 Hz to perhaps 800-1,000 Hz.

The injury criteria for fish from piling driving often cited comes from the FHWG criteria (2008). This guidance document reports 206 dBpeak re 1 μPa as peak level and 187 dB re 1 μPa2s cumulative SEL for fish over 2 grams. Because data on hearing capabilities exist for perhaps only 100 of the 29,000 or more extant species of fish (Popper et al. 2003), any extrapolation of hearing capabilities between different species, and especially those that are taxonomically distant must be done with the greatest caution (ICF Jones & Stokes 2009).

The FHWG criteria does not address behavioral effects of pile driving noise on fish, as little is known regarding the threshold levels for such effects. As a conservative measure, NOAA Fisheries and USFWS generally have used SPL 150 dB re 1 μPa as the threshold for behavioral effects to ESA-listed fish species (salmon and bull trout) for most biological opinions evaluating pile driving, citing that sound pressure levels in excess of SPL 150 dB re 1 μPa can cause temporary behavioral changes (startle and stress) that could decrease a fish’s ability to avoid predators (ICF Jones & Stokes 2009). Because no data on behavioral shifts in Atlantic sturgeon due to noise from similar construction activity exists, harassment distance for Atlantic sturgeon is not estimated in this report.

6.0 Summary of JASCO Underwater Modelling

Underwater noise modelling for the Project has been undertaken by JASCO Applied Sciences (JASCO). This section provides a brief overview of the JASCO modelling inputs and process, and a summary of the results relevant to this assessment. We have based this summary and our assessment on JASCO's 2014 report: *Underwater and in-air modelling study for construction and operation activities (NOAA Criteria Edition)*.

6.1 Model inputs

Construction noise source levels were estimated from previous measurements of similar equipment by JASCO, and scaled using the ratio of propulsion power (e.g., horsepower) of the measured and specified equipment. Suction piling source levels were assumed to be negligible to noise from the Heavy Lift Vessel and other associated construction equipment. In comparison, source levels for the unlikely impact pile driving alternative were estimated based on review and analysis of published sound level measurements from the available literature. For vessel source levels JASCO utilized source levels obtained from equivalent field measurements or from third party reports for their modelling effort.

Suction pile driving is performed using a pump that evacuates the water from the inside of a sealed pile. The pile driving force in this case results from the pressure difference. The noise source level of the pump is estimated to be low, about 138 dB re 1 µPa at 1 m (Laurinolli et al. 2005). The noise from the Heavy Lifting Vessel assisting the operation can therefore be considered as the dominating noise source during this activity and the noise from the water pump can be disregarded.

There is a remote possibility that impact pile driving might be needed should future geotechnical studies show that suction piling is not feasible at one ore more anchor locations instead of the planned suction piling. JASCO estimated source levels for impact piling on published sound level measurements. Impact piling source levels and 1/3 octave source spectra were derived from empirical equations given by MacGillivray et al. (2001) and estimated impact rates and piling timing from the Project's piling contractor. Impact piling sources were modelled at a depth of 7 meters below the sea surface.

Source levels for the LNGRV propulsion system were adopted from measured data of a similar vessel (*Suez Neptune* (HN1688)) as measurements of the proposed LNGRV vessel should be similar in magnitude as both vessels use the same propulsion system. JASCO used the measured data and adopted a suitable relative 1/3 octave band spectrum. The LNGRV source was modelled at a depth of 7 meters below the sea surface.

Bathymetry data was obtained from the National Geophysical Data Center's U.S. Coastal Relief Model, and geo-acoustic properties of the sea bed were estimated for seven locations covering off-shore, mid-depth and near-shore.

Sound speed profiles for each of the modelled sites were derived from temperature and salinity profiles from the U.S. Naval Oceanographic Office's Generalized Digital Environmental Model v3.0.

6.2 Modelled scenarios

JASCO modelled underwater noise from construction and operational sources for the Project, with results predicted for relevant operations at seven locations within the Project area. Modelling has been undertaken for four separate sound speed vs. depth profiles, representative of conditions in February, May, October and

December. Table 6-1, adopted from Tables 6 and 7 of the JASCO report, summarizes the modelled scenarios.

Table 6-1 Scenarios modelled by JASCO

Location	Project stage	Activity	Underwater Noise Sources	Months Modelled
Site 1: LNGRV transit	Operation	LNGRV transit	LNGRV movement	February, May, October, December
Site 2: Buoy 2	Operation	LNGRV mooring	LNGRV thrusters	February, May, October, December
		LNGRV weather vaning	LNGRV thrusters	
		Operational support	Operational Support Vessel	
		Regasification	LNGRV regasification equipment Support Vessel	
Site 2: Buoy 2	Construction	Suction pile installation	Heavy Lift Vessel	May, October
		Setting mooring lines, umbilical, PLEM	Suction piling (and if needed, anchor pile driving)	
			DP dive support vessel	
Site 3: Mainline offshore	Construction	Pipeline installation	DP pipelay vessel	May, October
		Pipeline lowering and backfilling	DP plow vessel	
Site 4: Mainline mid point	Construction	Pipeline installation	DP pipelay vessel	May, October
		Pipeline lowering and backfilling	DP plow vessel	
Site 5: Mainline near shore	Construction	Pipeline installation	DP pipelay vessel	May, October
		Pipeline lowering and backfilling	DP plow vessel	
Site 6: Power line cable crossing	Construction	Pipeline installation	DP pipelay vessel	May, October
		Pipeline lowering and backfilling	DP plow vessel	
Site 7: Transco Tie In	Construction	Pipeline lowering (jetting)	DP dive support vessel	May, October
		Pipeline lowering (jetting)	DP dive support vessel	

Location	Project stage	Activity	Underwater Noise Sources	Months Modelled
Sites 1-7: Various	Decommissioning, routine maintenance, and unplanned events	Would utilize similar sized operational and support vessels as above. Activities not modelled by JASCO.		Various

6.3 JASCO results

JASCO provided modelling results in the form of tabulated sound level threshold radii, measured in meters. Threshold distances are calculated from SPL (referred to as “per-pulse results”), and SELc (referred to as “cumulative SEL results”).

6.3.1 Noise metrics

SELc noise levels modelled by JASCO utilize a 24-hour accumulation time with the exception of impact piling. Impact piling uses an accumulation time corresponding to the 8,700 impacts estimated to be required to drive each pile, if in fact, the pile driving alternative is necessary at all. The piling contractor has suggested this will equate to an exposure time of approximately 2.5 hours per pile (if utilized).

NOAA’s Draft Guidance suggests a 1-hour accumulation period for SELc where animal behaviors/movements within the Project area are not known or cannot be modelled. The longer accumulation times used in modelling by JASCO will result in threshold radii that will be more conservative (i.e. larger in size) than if a 1 hour period was used.

JASCO did not report peak levels in their modelling results. In order to provide a level of objective assessment of peak levels from impact piling sources against the noise criteria, we used the relationship between dBpeak and dB_{rms} levels identified for impact piling as discussed in Appendix B. Because it is highly unlikely that impact piling will be utilized to install anchors for this Project, numbers for piling driving are reported in Appendix C for reference only.

6.3.2 Frequency weighting functions

Results are provided for unweighted M_{lf}, M_{mf}, M_{hf}, and M_{pp}, frequency weighting functions for LF cetaceans, MF cetaceans, HF cetaceans and phocid pinnipeds.

6.3.3 Sound level threshold radii

Tabulated sound level threshold radii are presented as both maximum range (R_{max}) and the 95% range ($R_{95\%}$) statistics. JASCO define $R_{95\%}$ as the radius of a circle, centered on the source, for which 95% of modelled spatial grid points have predicted sound levels at or above the given value. R_{max} is equivalent to $R_{100\%}$ as defined using the same methodology. In terms of impact on fauna, JASCO states that $R_{95\%}$ is equivalent to the range at which less than 5% of a uniformly distributed population would be exposed to sound at or above the given noise level. Because the population distribution of marine fauna (particularly cetaceans) is unlikely to be uniform throughout the Project area in time and space, this assessment uses the $R_{95\%}$ sound level thresholds. $R_{95\%}$ is less sensitive to small noise contour outliers scattered away from the main contour body, which would cause the $R_{100\%}$ sound level threshold radii to increase disproportionality to the size of the main contour body.

6.4 Construction phase results

This section summarizes the JASCO modelling results for the construction phase of the Project, in the form of threshold distances where the relevant criterion is exceeded.

Tables 6-2 and 6-3 provide the horizontal threshold distances from the underwater source location to the isopleth corresponding to criteria levels for cetaceans, sea turtles and fish for the construction phase of the Project. Tabulated results for cetaceans are direct excerpts from Section 4.3 of the JASCO report. Results for sea turtles and fish are based upon tabulated results in Appendix A of the JASCO report. Where multiple locations have been modelled we have reported the highest threshold distance from all locations.

6.5 Operation phase results

This section summarizes the JASCO modelling results for the operation phase of the Project, in the form of threshold distances where the relevant criterion is exceeded.

Tables 6-4 and Table 6-5 provide the horizontal threshold distances from the underwater source location to the isopleth corresponding to criteria levels for cetaceans, seals, sea turtles and fish for the operational phase of the Project. Results for cetaceans and seals are direct excerpts from Section 4.2 of the JASCO report. Results for sea turtles and fish are based upon tabulated results in Appendix A of the JASCO report. Where multiple locations have been modelled we have reported the highest threshold distance from all locations.

JASCO has split transit and mooring activities for per-pulse results, and combined these activities for cumulative SEL results. To assess the peak and rms levels, we have adopted the threshold distances from mooring activities, as mooring produces higher noise levels than transit activities.

Table 6-2 Summary of relevant construction phase threshold distances for Cetaceans

Activity	Month	LF Cetaceans		MF Cetaceans		HF Cetaceans	
		PTS Threshold [m]	TTS Threshold [m]	PTS Threshold [m]	TTS Threshold [m]	PTS Threshold [m]	TTS Threshold [m]
Suction piling	May	124	3,110	<20(1)	438	209	3,790
	Oct	121	2,850	<20(1)	400	194	3,610
Lateral pipeline installation	May	247	4120	168	375	193	3,140
	Oct	238	3630	168	349	191	2,920
Lateral pipeline lowering and backfilling	May	288	1,950	<20(1)	288	288	1,060
	Oct	288	1,790	<20(1)	290	288	990
Mainline installation	May	343	4,820	219	479	262	3,780
	Oct	327	4,510	219	453	260	3,580
Mainline lowering and backfilling	May	327	2,190	<20(1)	327	326	1,350
	Oct	338	2,040	<20(1)	327	326	1,260
Pipeline lowering by jetting	May	165	3,440	<20(1)	529	270	4,090
	Oct	143	3,230	<20(1)	494	253	3,890

Table 6-3 Summary of relevant construction phase threshold distances for seals, sea turtles and fish

Activity	Month	Seals		Sea Turtles		Fish	
		PTS Threshold [m]	TTS Threshold [m]	Harm Threshold [m]	Harassment Threshold [m]	Harm Threshold [m]	Harassment Threshold [m]
Suction Piling	May	157	1,660	N/A(2)	<20(1)	1,400	N/A(3)
	Oct	150	1,510		<20(1)	900	
Lateral pipeline installation	May	274	2190		<20(1)	850	
	Oct	260	1980		<20(1)	1050	
Lateral pipeline lowering and backfilling	May	288	990		<20(1)	1050	
	Oct	290	895		<20(1)	650	
Mainline installation	May	379	2590		<20(1)	1500	
	Oct	367	2440		<20(1)	1400	
Mainline lowering and backfilling	May	327	1220		<20(1)	900	
	Oct	328	1140		<20(1)	850	
Pipeline lowering by jetting	May	220	1920		<20(1)	1050	
	Oct	205	1780		<20(1)	1050	

Notes:

(1) We have assessed both SELc and dBpeak noise levels for impact piling against the NOAA criteria for Cetaceans. Levels corresponding to the relevant noise criterion are predicted to occur within threshold distances of less than 20 m according to the JASCO tabulated results.

(2) Because the harm criterion for turtles is a dBpeak criterion, and threshold distances in terms of dBpeak are not available, distances could not be calculated for the harm threshold for turtles.

(3) Because no data on behavioral shifts (harassment) in Atlantic sturgeon due to noise from similar construction activity exists, harassment distance for Atlantic sturgeon was not estimated.

Table 6-4 Summary of relevant operation phase threshold distances for cetaceans

Activity	Month	LF Cetaceans		MF Cetaceans		HF Cetaceans	
		PTS Threshold [m]	TTS Threshold [m]	PTS Threshold [m]	TTS Threshold [m]	PTS Threshold [m]	TTS Threshold [m]
LNGRV transit and mooring	Feb	270	16,300	270	ND	270	35,000
	May	270	18,800	270	ND	270	36,300
	Oct	270	22,500	270	ND	270	37,300
	Dec	270	18,700	270	ND	270	36,600
LNGRV weather vaning	Feb	244	4,550	<20(1)	384	157	3,320
	May	239	4,020	<20(1)	375	152	3,090
	Oct	228	3,540	<20(1)	344	147	2,860
	Dec	238	4,300	<20(1)	374	154	3,180
Regasification	Feb	<20(1)	729	<20(1)	705	21	776
	May	<20(1)	728	<20(1)	705	21	771
	Oct	<20(1)	725	<20(1)	705	21	758
	Dec	<20(1)	728	<20(1)	705	21	766

Notes:

(1) Levels corresponding to the relevant noise criterion are predicted to occur within threshold distances of less than 20 m according to the JASCO tabulated results.

(2) ND=No accurate data for MF cetaceans available for TTS.

Table 6-5 Summary of relevant operation phase threshold distances for seals, sea turtles and fish

Activity	Month	Seals		Sea Turtles		Fish	
		PTS Threshold [m]	TTS Threshold [m]	Harm Threshold [m]	Harassment Threshold [m]	Harm Threshold [m]	Harassment Threshold [m]
LNGRV transit and mooring	Feb	270	914	N/A(1)	240	423(2)	N/A(4)
	May	270	903		240	410(2)	
	Oct	270	779		240	385(2)	
	Dec	270	861		240	403(2)	
LNGRV weather vaning	Feb	281	2,380		<20(3)	1,800	
	May	274	2,240		<20(3)	1,700	
	Oct	251	1,990		<20(3)	1,700	
	Dec	268	2,290		<20(3)	1,800	
Regasification	Feb	<20(3)	717		<20(3)	717	
	May	<20(3)	717		<20(3)	717	
	Oct	<20(3)	717		<20(3)	717	
	Dec	<20(3)	717		<20(3)	717	

Notes:

(1) The harm criterion for turtles is a dBpeak criterion. Since threshold distances in terms of dBpeak have not been provided, no predictions can be made.

(2) Threshold distances were not predicted by Jasco for levels less than 190 dB SELc for fish during LNGRV transit and mooring, therefore the Harm threshold distance for the 190 dB level was used.

(3) Levels corresponding to the relevant noise criterion are predicted to occur within threshold distances of less than 20m according to the JASCO tabulated results.

(4) Because no data on behavioral shifts (harassment) in Atlantic sturgeon due to noise from similar construction activity exists, harassment distance for Atlantic sturgeon was not estimated.

7.0 Risk Analysis

Based on Neubert and Sullivan's (2014) abundance estimates we assess risk from underwater sound sources to nine protected marine mammals, four sea turtles and one fish species that could potentially transit the Project area on a seasonal basis as described in Section 4 (Tables 4-3 and 4-4).

As described in Section 5 of this report, each of these species can be grouped into hearing categories as defined by NOAA (2014):

- LF cetaceans (North Atlantic right whales, humpback whales, and fin whales);
- MF cetaceans (bottlenose dolphins and common dolphins);
- HF cetaceans (harbor porpoises);
- Phocid pinnipeds (harbor seals, harp seals and gray seals);
- Sea Turtles (loggerhead, Kemp's ridley, green, and leatherback sea turtles); and
- Fish (Atlantic sturgeon).

Using the risk framework described below we assess risk to each of these groups for each of the Project activities that will generate underwater sound. Based on the distances for PTS (Harm) and TTS (Harassment) as defined by NOAA we rank each Project activity with respect to groups of species that could potentially transit the Project area.

7.1 Risk analysis framework

The risk level is determined by first selecting the appropriate consequence and likelihood descriptors from the definitions included in Table 7-1 and Table 7-2.

Consequence levels reflect the impact that exposure to underwater sound from the Project would have on a species. In determining the consequence level we have considered the sources of sound from each Project activity relative to existing noise levels in the environment (as discussed in Section 2).

Table 7-1 Risk analysis framework consequence descriptors

Consequence Level to Impacted Species				
Negligible	**Minor**	**Moderate**	**Major**	**Extreme**
Minimal impact in a localized area of little or no consequence to the species.	Low impact in a localized or regional area with a functional recovery within one year.	Medium impact in a localized or regional area with a functional recovery of 1 to 5 years.	High impact in a localized or regional area with a functional recovery within 5 to 10 years.	Very high impact in a regional area with functional recovery in greater than 10 years, if at all.

Likelihood levels consider how probable it is for members of a functional hearing group or species to be impacted by exposure to noise from an activity associated with the Project. To determine likelihood we considered the following: the temporary and spatially explicit nature of the construction phase of the Project; the transient and seasonal nature of the species moving through the Project area, and the ability of animals to move away from potential sound sources.

Table 7-2 Risk analysis framework likelihood levels

Likelihood of Impact to Individual or Species from Sound Source				
Rare	**Unlikely**	**Likely**	**Almost certain**	**Certain**
Highly unlikely to occur but theoretically possible.	May occur within the life of the Project or activity.	Likely to occur more than once during the life of the Project or activity.	Very likely to occur during the life of the Project or activity.	Will occur as a result of the Project or activity.

Risk is then determined by identifying the matching risk row and consequence column of the risk matrix shown below in Table 7-3, with the risk level given by the matrix cell which the risk row and consequence column intersect at.

Table 7-3 Risk assessment matrix

Likelihood	Consequence				
	Negligible	**Minor**	**Moderate**	**Major**	**Extreme**
Rare	Low	Low	Low	Medium	High
Unlikely	Low	Low	Medium	Medium	High
Likely	Low	Medium	Medium	High	High
Almost certain	Medium	Medium	High	High	Critical
Certain	Medium	Medium	High	Critical	Critical

7.2 Construction phase risk analysis

Because impact piling was assessed to have the highest potential for sound generation (over the widest area) associated with the proposed Project, the decision was made that the anchors will be installed at the Port using suction piles. A verification study (Moffatt and Nichol 2014) commissioned by Liberty confirmed this approach. All sound sources from the construction phase of the Project are considered to have a Minor impact to species of marine mammals, turtles and fish (See Tables 6-2 to 6-5 above and Section 4 of Jasco 2014) relative to “harm” criteria (PTS). Because impact piling is not intended to be used for anchor placement it is only mentioned in the following sections for comparison purposes. For additional details about the potential impacts from pile driving to functional hearing groups see Appendix C.

Because the behavioral response of marine mammals, sea turtles, and fishes to a perceived marine sound depends on a range of factors, including: (1) the sound pressure level (SPL); (2) frequency, duration, and novelty of the sound; (3) the physical and behavioral state of the animal at the time of perception; and (4) the ambient acoustic features of the environment (Hildebrand 2004) it is more difficult to predict behavioral shifts due to anthropogenic sounds. The radiation of sound to marine waters during the construction phase of this Project will be within the immediate vicinity of the Project and effects are expected to be temporary, hence “harassment” (TTS) for all species are ranked as Negligible to Minor.

Although species abundance varies by season in the Project area the likelihood of “harm” (PTS) or “harassment” (TTS) from the Project to individuals or species due to underwater sound is Rare to Unlikely because of the transient and seasonal nature of the species moving through the Project area, and the ability of animals to move away from sound sources.

Overall risk from underwater sound for each functional group and species is determined by identifying the matching risk row and consequence column of the risk matrix for the construction phase of the Project below.

7.2.1 LF cetaceans (whales)

As described in detail in Section 4, there are three whale species listed as endangered under the ESA that could potentially transit the Project area that are classified as LF cetaceans: fin whales (*Balaenoptera physalus*), humpback whales (*Megaptera novaeangliae*), and the North Atlantic right whale (*Eubalaena glacialis*).

All sound sources from the construction phase of the Project are considered to have Minor consequences to LF cetaceans with respect to “harm” (PTS) and Minor consequence to LF cetaceans with respect to TTS. Because North Atlantic right whales are rarely likely to occur in the Project area they are ranked as Rare in terms of Likelihood. Fin whales and humpback whales have the potential to transit the Project area for a temporary period of time, but are also Unlikely to dwell within the small areas encompassing the TTS or PTS threshold zones for the modelled period of 24 hours so are ranked as Unlikely in terms of Likelihood.

Suction piling noise levels are predicted to exceed the TTS threshold for LF cetaceans within 3.5 km of piling, and the PTS criterion within 130 m of suction piling. We consider the likelihood of TTS or PTS occurrence from suction piling to be Rare-Unlikely, as it is highly unlikely that a LF cetacean would dwell within the small areas encompassing the TTS or PTS threshold zones for the modelled period of 24 hours. The overall risk level to all three LF cetaceans from suction piling associated with the Project is Low for PTS and TTS occurrence.

Installation of the lateral pipeline will produce noise levels that are predicted to exceed the PTS criterion for LF cetaceans within 250 m. The PTS threshold distance for lowering and backfilling activities for the lateral pipeline is 300 m. The TTS setback distances are 4.2 km and 2 km respectively. We consider the likelihood of PTS or TTS occurrence for LF cetaceans from Lateral pipeline installation to be Rare-Unlikely, as it is highly unlikely that a cetacean would dwell within the given small PTS or TTS threshold zones for 24 hours, even if the construction timeframe of the pipeline sections overlaps the cetacean season. The overall risk level to all three LF cetaceans from lateral pipeline installation is Low for PTS and TTS occurrence.

Activities associated with the installation of the Mainline have threshold distances similar in magnitude to those from installation of the Lateral pipelines. The PTS criterion for LF cetaceans is exceeded within 350 m for installation and 340 m for lowering and backfilling. The TTS setback distances are 5 km and 2.2 km respectively. We consider the likelihood of LF cetaceans incurring PTS or TTS from Mainline installation to be Rare-Unlikely, as it is highly unlikely that a cetacean would dwell within the given small PTS or TTS threshold zones for 24 hours, even if the construction timeframe of the pipeline sections overlaps the LF cetacean season. The overall risk level to all three LF cetacean species from Mainline installation is Low for PTS and TTS occurrence.

Lowering of the pipeline using jetting is predicted to have similar threshold distances to suction piling. The PTS threshold distance is 170 m and the TTS threshold distance is 3.5 km. We consider the likelihood of a cetacean incurring PTS or TTS from this activity to be Rare-Unlikely, as it is highly Unlikely that a cetacean would dwell within the given small PTS or TTS threshold zones for 24 hours. The overall risk level to the three LF cetacean species from pipeline lowering using jetting is Low for PTS and TTS occurrence.

7.2.2 Mid frequency cetaceans (bottlenose and common dolphins)

Two marine mammal species protected under the MMPA, bottlenose dolphins (*Tursiops truncatus*) and common dolphins (*Delphinus delphis*) could potentially transit the Project area and are classified as MF cetaceans. All sound sources from the construction phase of the Project are considered to have Minor consequences to the two species of MF cetaceans with respect to “harm” (PTS) and Negligible consequence with respect to TTS. Because bottlenose and common dolphins have the potential to transit the Project area in low numbers in some seasons (see Table 4-3) and because of their ability to move away from sound sources, likelihood for PTS is Rare and TTS is ranked as Unlikely.

Noise levels from suction piling are predicted to exceed the TTS threshold for MF cetaceans within approximately 450 m of piling, and the PTS criterion within 20 m of suction piling. We consider the likelihood of TTS from suction piling noise to be Unlikely and PTS occurrence to be Rare; as it is improbable that a MF cetacean would dwell within the small areas encompassing the TTS or PTS threshold zones for the modelled accumulation period of 24 hours. The overall risk level to both bottlenose and common dolphins from suction piling associated with the Project is Low for PTS and TTS occurrence.

Installation of the Lateral pipeline will produce noise levels that are predicted to exceed the PTS criterion for MF cetaceans within 170 m. The PTS threshold distance for lowering and backfilling activities for the lateral pipeline is 20 m. The TTS setback distances are 380 m and 290 m, respectively. We consider the likelihood of PTS occurrence from Lateral pipeline construction to be Rare, and TTS occurrence to be Unlikely, as it is highly improbable that a cetacean would dwell within these small PTS or TTS threshold zones for 24 hours. The overall risk level to both species of MF cetaceans from Lateral pipeline installation is Low for PTS and TTS occurrence.

Activities associated with the installation of the Mainline have threshold distances similar in magnitude to those from installation of the Lateral pipelines. The PTS criterion for MF cetaceans is exceeded within 220 m for installation and 20 m for lowering and backfilling. The TTS setback distances for the same activities are 480 m and 330 m respectively. We consider the likelihood of MF cetaceans incurring PTS from Mainline installation to be Rare and TTS to be Unlikely, as it is highly improbable that a cetacean would dwell within the given PTS/TTS threshold zones for 24 hours. The overall risk level to both species of MF cetaceans that could transit the Project area from Mainline installation is Low for PTS and TTS occurrence.

Lowering of the pipeline using jetting is predicted to have similar threshold distances to suction piling. The PTS threshold distance is 20 m and the TTS threshold distance is 530 m. We consider the likelihood of a cetacean incurring PTS to be Rare and TTS to be Unlikely, as it is highly unlikely that a cetacean would dwell within the given small PTS or TTS threshold zones for 24 hours. The overall risk level to both species of MF cetaceans from pipeline lowering using jetting is Low for PTS and TTS occurrence.

7.2.3 High frequency cetaceans (harbor porpoise)

Harbor porpoises (*Phocoena phocoena*) are the only HF cetacean with the potential to transit the Project area and in low abundances (Table 4-3). All sound sources from the construction phase of the Project are considered to have Minor consequences with respect to “harm” (PTS) and Negligible consequence with respect to TTS to harbor porpoises. Because harbor porpoises could transit the Project area in low numbers in some seasons (see Table 4-3) and because of their ability to move away from sound sources, likelihood for PTS is Rare and for TTS is Unlikely.

Noise levels from suction piling are predicted to exceed the TTS threshold for harbor porpoises within 3.8 km of piling, and the PTS criterion within 210 m of suction piling. The short duration of suction piling activities during construction, and the timing of activities outside of season for HF cetaceans suggest the likelihood of TTS occurrence from suction piling noise to be Unlikely and the likelihood of PTS occurrence to be Rare. The overall risk level to harbor porpoises from suction piling associated with the Project is Low for PTS and TTS occurrence.

Installation of the Lateral pipeline will produce noise levels that are predicted to exceed the TTS criterion for HF cetaceans within 3.1 km. The TTS threshold distance for lowering and backfilling activities for the Lateral pipeline is 1.1 km. The PTS distances are 193 m and 288 m respectively. We consider the likelihood of TTS occurrence from the activities to be Unlikely and the likelihood of PTS occurrence to be Rare, as it is improbable that a harbor porpoise would dwell within these small PTS or TTS threshold zones for the entire

24 hour accumulation period. The overall risk level to harbor porpoises from lateral pipeline installation is Low for PTS and TTS occurrence.

Activities associated with the installation of the Mainline have threshold distances similar in magnitude to those from installation of the Lateral pipelines. The PTS criterion for HF cetaceans is exceeded within 270 m for installation and 330 m for backfilling and lowering. The TTS setback distances for the same activities are 3.8 km and 1.4 km respectively. We consider the likelihood of TTS occurrence from the activities associated with installation of the Mainline to be Unlikely and the likelihood of PTS occurrence to be Rare. The overall risk level to harbor porpoises from Mainline installation is Low for PTS and TTS occurrence.

Lowering of the pipeline using jetting is predicted to have similar magnitude of threshold distances to suction piling. The PTS threshold distance is 270 m and the TTS threshold distance is 4.1 km. We consider the likelihood of TTS occurrence from the activities associated with installation of mainline pipeline to be Unlikely and the likelihood of PTS occurrence to be Rare. The overall risk level to harbor porpoises from pipeline lowering using jetting is Low for PTS and TTS occurrence.

7.2.4 Phocid pinnipeds (seals)

Harbour seals (*Phoca vitulina*), gray seals (*Halichoerus grypus*), and harp seals (*Pagophilus groenlandicus*) are categorized as phocid pinnepids with respect to hearing categories and could transit the Project area in small numbers (Table 4-3). Species of phocid pinnipeds are only likely to transit the Project area at the beginning and/or end of the construction phase because they are typically present in the New York Bight area in autumn, winter and spring (Table 4-4). All sound sources from the construction phase of the Project are considered to have Minor consequences with respect to “harm” (PTS) and Minor consequence with respect to TTS for seals. Because the three species of seals could transit the Project area in low numbers in some seasons (see Table 4-3) and because of their ability to move away from sound sources, likelihood for PTS is Rare and for TTS is Unlikely.

Suction piling noise levels are predicted to exceed the TTS threshold for seals within 1.7 km of piling, and the PTS criterion within 160 m of suction piling. We consider the likelihood for PTS is Rare and for TTS is Unlikely, as it is highly Unlikely that a phocid pinniped would dwell within the small areas encompassing the TTS or PTS threshold zones for the modelled accumulation period of 24 hours outside of season. The overall risk level to seals from suction piling associated with the Project is Low for PTS and TTS occurrence.

Installation of the Lateral pipeline will produce noise levels that are predicted to exceed the PTS criterion for seals within 280 m. The PTS threshold distance for lowering and backfilling activities for the Lateral pipeline is 290 m. The TTS setback distances are 2.1 km and 1 km respectively. We consider the likelihood of PTS occurrence for seals from Lateral pipeline installation to be Rare and for TTS to be Unlikely, as it is highly Unlikely that a pinniped would dwell within the given small PTS or TTS threshold zones for 24 hours, even if the construction timeframe of the pipeline sections overlapped the phocid pinniped season. The overall risk level to seals from Lateral pipeline installation is Low for PTS and TTS occurrence.

Activities associated with the installation of the Mainline have threshold distances similar in magnitude to those from installation of the Lateral pipelines. The PTS criterion for seals is exceeded within 380 m for installation and 330 m for lowering and backfilling. The TTS setback distances are 2.6 km and 1.3 km respectively. We consider the likelihood of seals incurring PTS from Mainline installation to be Rare and for TTS to be Unlikely, as it is highly Unlikely that a pinniped would dwell within the predicted small PTS or TTS threshold zones for 24 hours, even if the construction timeframe of the pipeline sections overlaps the phocid pinniped season. The overall risk level to the three seal species from Mainline installation is Low for PTS and TTS occurrence.

Lowering of the pipeline using jetting is predicted to have similar threshold distances to suction piling. The PTS threshold distance is 220 m and the TTS threshold distance is 2.0 km. We consider the likelihood of a pinniped incurring PTS from this activity to be Rare and TTS to be Unlikely, as it is highly unlikely that a pinniped would dwell within the predicted small PTS or TTS threshold zones for 24 hours. The overall risk level to all three seals from pipeline lowering using jetting is Low for PTS and TTS occurrence.

Table 7-4 summarizes risk ratings for construction phase activities for marine mammals.

Table 7-4 Risk analysis – construction phase, marine mammals

Functional Hearing Group	Item	Consequence		Likelihood		Risk	
		TTS	PTS	TTS	PTS	TTS	PTS
LF Cetaceans (humpback, fin and North Atlantic right whales)	Suction piling	Minor	Minor	Rare	Rare	Low	Low
	Lateral pipeline installation	Minor	Minor	Rare	Rare	Low	Low
	Lateral pipeline lowering and backfilling	Minor	Minor	Rare	Rare	Low	Low
	Mainline installation	Minor	Minor	Rare	Rare	Low	Low
	Mainline lowering and backfilling	Minor	Minor	Rare	Rare	Low	Low
	Pipeline lowering by jetting	Minor	Minor	Rare	Rare	Low	Low
MF Cetaceans (bottlenose and common dolphins)	Suction piling	Negligible	Minor	Unlikely	Rare	Low	Low
	Lateral pipeline installation	Negligible	Minor	Unlikely	Rare	Low	Low
	Lateral pipeline lowering and backfilling	Negligible	Minor	Unlikely	Rare	Low	Low
	Mainline installation	Negligible	Minor	Unlikely	Rare	Low	Low
	Mainline lowering and backfilling	Negligible	Minor	Unlikely	Rare	Low	Low
	Pipeline lowering by jetting	Negligible	Minor	Unlikely	Rare	Low	Low
HF cetaceans (Harbor porpoises)	Suction piling	Negligible	Minor	Unlikely	Rare	Low	Low
	Lateral pipeline installation	Negligible	Minor	Unlikely	Rare	Low	Low
	Lateral pipeline lowering and backfilling	Negligible	Minor	Unlikely	Rare	Low	Low
	Mainline installation	Negligible	Minor	Unlikely	Rare	Low	Low
	Mainline lowering and backfilling	Negligible	Minor	Unlikely	Rare	Low	Low
	Pipeline lowering by jetting	Negligible	Minor	Unlikely	Rare	Low	Low
Phocid Pinnipeds (seals)	Suction piling	Negligible	Minor	Unlikely	Rare	Low	Low
	Lateral pipeline installation	Negligible	Minor	Unlikely	Rare	Low	Low
	Lateral pipeline lowering and backfilling	Negligible	Minor	Unlikely	Rare	Low	Low
	Mainline installation	Negligible	Minor	Unlikely	Rare	Low	Low
	Mainline lowering and backfilling	Negligible	Minor	Unlikely	Rare	Low	Low
	Pipeline lowering by jetting	Negligible	Minor	Unlikely	Rare	Low	Low

7.2.5 Sea turtles

Four species of sea turtles, including loggerheads (*Caretta caretta*), Kemp's ridley sea turtles (*Lepidochelys kempi*), green sea turtles (*Chelonia mydas*), and leatherbacks (*Dermochelys coriacea*) could also potentially transit the Project area in summer (Table 4-3 and 4-4). The radiation of sound to marine waters from construction will be within the immediate vicinity of the Project and is expected to be temporary; therefore all sound sources from the construction phase of the Project are considered to have a Minor impact to all four species of sea turtles relative to harm and harassment criteria.

The likelihood of harassment from the Project to sea turtles is considered Rare because construction activities have been predicted based on a 24 hour cumulative SEL exposure. As it is highly unlikely that a sea turtle would inhabit the area within the Harassment threshold distance for an entire 24 hour period, we consider the likelihood level for harassment to be Rare.

Suction piling underwater noise levels are predicted to be in excess of the Harassment criterion for sea turtles within 20 m of the Heavy Lift Vessel noise source. Because suction piling levels have been predicted based upon a 24 hour cumulative SEL exposure and it is highly unlikely that an animal would inhabit the 20 m area within the Harassment threshold distance for an entire 24 hour period, we consider the likelihood level for harassment to be Rare. The overall risk level for Harassment to all four species of sea turtles from suction piling is Low.

Installation of the Lateral pipelines, Mainline pipeline, lowering and backfilling activities, and jetting will also produce sound levels that are predicted to exceed the Harassment criterion for turtles within a 20 m radius of construction activities. The overall risk level to loggerhead, leatherback, Kemp's ridley and green turtles due to Project construction activities is Low.

Table 7-5 summarizes risk ratings for construction phase activities for sea turtles.

Table 7-5 Risk analysis – construction phase, sea turtles

	Activity Relative to Harassment Criteria	Consequence	Likelihood	Risk
Sea Turtles (leatherback, loggerhead, green and Kemp's ridley sea turtles)	Suction piling	Minor	Rare	Low
	Lateral pipeline installation	Minor	Rare	Low
	Lateral pipeline lowering and backfilling	Minor	Rare	Low
	Mainline installation	Minor	Rare	Low
	Mainline lowering and backfilling	Minor	Rare	Low
	Pipeline lowering by jetting	Minor	Rare	Low

7.2.6 Fish (Atlantic Sturgeon)

Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) is the only fish species known to be present in the waters of the NY Bight year-round with five DPSs listed as endangered or threatened under the ESA. Elevated underwater noise levels from the Project are anticipated to have a minor consequence where the Harm criterion is exceeded. Because no data on behavioral shifts in Atlantic sturgeon due to noise from similar construction activity exists, harassment distances for Atlantic sturgeon are not estimated in this report.

Suction piling underwater noise levels are predicted to exceed the Harm criterion within 1.4 km of the suction piling source for fish. Suction piling harm threshold distances have been predicted based upon a 24 hour cumulative exposure. We consider it improbable that Atlantic sturgeon would inhabit the area within the threshold distances for an entire 24 hour period without changing behavior to avoid the noise. As such we consider the likelihood level for suction piling to be Unlikely and the consequences to the species to be Minor. The risk level to Atlantic Sturgeon from suction piling is Low.

Installation of the Lateral pipeline will produce noise levels that are predicted to exceed the Harm criterion within 1.5 km of the source. For lowering and backfilling activities, the Harm threshold is within 700 m. The installation of the Mainline is predicted to have threshold distances of 1.5 km and lowering and backfilling activities have a Harm threshold distance of 1 km. Lowering of the pipeline using jetting is predicted to have a Harm threshold distance of 1.1 km. These are similar threshold distances to suction piling, and we consider the likelihood level to be Unlikely and the consequences to the species to be Minor. The overall risk level to Atlantic Sturgeon from Project construction activities is Low.

Table 7-6 summarizes risk ratings for construction phase activities for Fish.

Table 7-6 Risk analysis – construction phase, fish

	Activity Relative to Harm Criteria	Consequence	Likelihood	Risk
Atlantic Sturgeon	Suction piling	Minor	Unlikely	Low
	Lateral pipeline installation	Minor	Unlikely	Low
	Lateral pipeline lowering and backfilling	Minor	Unlikely	Low
	Mainline installation	Minor	Unlikely	Low
	Mainline lowering and backfilling	Minor	Unlikely	Low
	Pipeline lowering by jetting	Minor	Unlikely	Low

7.3 Operation phase risk analysis

All sound sources from the operational phase of the Project are considered to have a Negligible to Minor consequences to species of marine mammals, turtles and fish (See Tables 6-2 to 6-5 above and Section 4 of Jasco 2014) relative to harm criteria (PTS). The radiation of sound to marine waters during operations is expected to be temporary, hence “harassment” (TTS) for all species are also ranked as Negligible to Minor.

Although species abundance varies by season and species in the Project area the likelihood of “harm” (PTS) or “harassment” (TTS) from the Project to individuals or species due to underwater sound is Rare to Unlikely because of the transient and seasonal nature of the species moving through the Project area, and the ability of animals to move away from sound sources.

Overall risk from underwater sound during operations for each functional group and species is determined by identifying the matching risk row and consequence column of the risk matrix.

7.3.1 Low frequency cetaceans (whales)

Noise levels predicted for LNGRV transit and mooring activities show the TTS criterion to be exceeded for LF cetaceans within 23 km of the source, and PTS threshold to be exceeded for LF cetaceans within 270 m. The total time for transit and mooring activities to occur was modelled as 21 hours (i.e. 20 hours to transit, and 1 hour for mooring activities). Given the steady state nature of the thruster noise source, the transient nature of ESA listed whales in the area and the ability of animals to move away from the sound source, it is considered unlikely that a cetacean would stay within the TTS or PTS threshold distance for the entire accumulation time of 21 hours, and as such we consider the Likelihood of LNGRV transit causing TTS or PTS in LF cetaceans to be Rare. The overall risk level to cetaceans (including fin whales, humpback whales and North Atlantic right whales) for LNGRV transit and mooring is Low for both PTS and TTS occurrence.

LNGRV weather vaning noise is predicted to exceed the TTS criterion for LF cetaceans within 4.5 km of the vessel. The PTS criterion is predicted to be exceeded within 250 m. These threshold distances correspond to an accumulation time of 24 hours. We note that it is likely for the LNGRV to use thrusters to weather vane while moored; however, we consider it unlikely that a LF cetacean will be within the PTS or TTS threshold distances from the LNGRV for this accumulation time. We believe that the likelihood of a fin whale, humpback whale or North Atlantic right whale suffering PTS or TTS from LNGRV weather vaning to be Rare. Therefore, the overall risk level for PTS or TTS occurring for these LF cetaceans from LNGRV weather vaning is Low.

Regasification activities are predicted to exceed the TTS criterion within a threshold distance 750 m of the LNGRV and support vessel. The PTS criterion threshold is given as less than 20 meters. We consider it unlikely that a LF cetacean will be within the threshold distances for the modelled 24 hours accumulation time. We believe the likelihood of a LF cetacean suffering TTS or PTS to be Rare. The overall risk level for TTS and PTS is Low.

7.3.2 Mid frequency cetaceans (bottlenose and common dolphins)

Noise levels predicted for LNGRV transit and mooring activities show the PTS threshold to be exceeded for MF cetaceans within 270 m. Because this threshold distance is modelled for 24 hours of continuous exposure, we consider the Likelihood of LNGRV transit causing TTS or PTS in bottlenose or common dolphins to be Rare. The overall risk level to bottlenose or common dolphins for LNGRV transit and mooring is Low for PTS occurrence and Low for TTS occurrence.

LNGRV weather vaning noise is predicted to exceed the TTS criterion for MF cetaceans within 390 m of the vessel. The PTS criterion is predicted to be exceeded within 20 m. As these threshold distances are for 24 hours of continuous exposure, we suggest that the likelihood of bottlenose or common dolphins suffering PTS or TTS from LNGRV weather vaning to be Rare. Therefore, the overall risk level for PTS or TTS occurring for bottlenose or common dolphins from LNGRV weather vaning is Low.

Regasification activities are predicted to exceed the TTS criterion within a threshold distance 705 m of the LNGRV and Support Vessel. The PTS criterion threshold is given as less than 20 meters. As these threshold distances are for 24 hours of continuous exposure, we suggest the likelihood of bottlenose or common dolphins suffering TTS or PTS to be Rare. The overall risk level for TTS and PTS for this species is Low.

7.3.3 High frequency cetaceans (harbor porpoises)

Noise levels predicted for LNGRV transit and mooring activities show the TTS criterion to be exceeded for HF cetaceans (harbor porpoises) within 38 km of the source, and PTS threshold to be exceeded for HF cetaceans within 270 m. As these threshold distances are for 24 hours of continuous exposure, we consider the Likelihood of LNGRV transit causing TTS or PTS in harbor porpoises to be Rare. The overall risk level to harbor porpoises for LNGRV transit and mooring is Low for PTS and TTS occurrence.

LNGRV weather vaning noise is predicted to exceed the TTS criterion for HF cetaceans within 3.4 km of the vessel. The PTS criterion is predicted to be exceeded within 160 m. As these threshold distances are for 24 hours of continuous exposure, we suggest that the likelihood of a harbor porpoise suffering PTS or TTS from LNGRV weather vaning to be Rare. Therefore, the overall risk level for PTS or TTS occurring for harbor porpoises from LNGRV weather vaning is Low.

Regasification activities are predicted to exceed the TTS criterion within a threshold distance of 780 m of the LNGRV and Support Vessel. The PTS criterion threshold is given as 21 m. As these threshold distances are for 24 hours of continuous exposure, we suggest the likelihood of harbor porpoises suffering TTS or PTS to be Rare. The overall risk level for TTS and PTS is Low.

7.3.4 Phocid pinnipeds (seals)

Noise levels predicted for LNGRV transit and mooring activities show the TTS criterion to be exceeded for seals within 920 m of the source, and PTS threshold to be exceeded for seals within 270 m. LNGRV weather vaning noise is predicted to exceed the TTS criterion for seals within 2.4 km of the vessel and the PTS criterion is predicted to be exceeded within 290 m. Regasification activities are predicted to exceed the TTS criterion within a threshold distance of 720 m of the LNGRV and Support Vessel. As these threshold distances are for 24 hours of continuous exposure, we suggest that the likelihood of seals suffering PTS or TTS from LNGRV transit, mooring or weather vaning or from regasification to be Rare. Therefore, the overall risk level for PTS or TTS occurring for seals from LNGRV transit, mooring or weather vaning or regasification is Low.

The PTS criterion threshold is given as 20 meters. As these threshold distances are for 24 hours of continuous exposure, we suggest the likelihood of seals suffering TTS or PTS to be Rare. The overall risk level for TTS and PTS is Low.

Table 7-7 summarizes risk ratings for Operation phase activities for marine mammals.

Table 7-7 Risk analysis – operation phase, marine mammals

Functional Hearing Group	Activity	Consequence		Likelihood		Risk	
		TTS	PTS	TTS	PTS	TTS	PTS
LF Cetaceans (Humpback, Fin and North Atlantic Right Whales)	LNGRV transit and mooring	Minor	Minor	Rare	Rare	Low	Low
	LNGRV weather vaning	Minor	Minor	Rare	Rare	Low	Low
	Regasification	Minor	Minor	Rare	Rare	Low	Low
MF Cetaceans (Bottlenose and Common Dolphins)	LNGRV transit and mooring	Negligible	Minor	Rare	Rare	Low	Low
	LNGRV weather vaning	Negligible	Minor	Rare	Rare	Low	Low
	Regasification	Negligible	Minor	Rare	Rare	Low	Low
HF cetaceans (Harbor Porpoises)	LNGRV transit and mooring	Negligible	Minor	Rare	Rare	Low	Low
	LNGRV weather vaning	Negligible	Minor	Rare	Rare	Low	Low
	Regasification	Negligible	Minor	Rare	Rare	Low	Low
Phocid Pinnipeds (xeals)	LNGRV transit and mooring	Negligible	Minor	Rare	Rare	Low	Low
	LNGRV weather vaning	Negligible	Minor	Rare	Rare	Low	Low
	Regasification	Negligible	Minor	Rare	Rare	Low	Low

7.3.5 Sea turtles

Underwater noise levels for LNGRV transit and mooring are predicted to exceed the Harassment criterion for turtles within a threshold distance of 240 m. Similar to cetaceans, it is considered unlikely that a turtle would stay within the threshold distance for Harassment without changing behavior to avoid noise. As such, we consider the Likelihood of LNGRV transit noise causing Harassment to listed species of sea turtles to be Rare. The risk level to turtles for Harm from LNGRV mooring is Low.

Weather vaning of the LNGRV is predicted to produce noise levels which will exceed the Harassment criterion for turtles within a threshold distance of less than 20 m for an accumulation time of 24 hours. We consider the Likelihood of LNGRV weather vaning noise causing Harassment to listed species of sea turtles to be Rare, and the risk level for Harassment is therefore Low.

Regasification activities are predicted to exceed the Harassment criterion within a threshold distance 750 m of the LNGRV and Support Vessel for an accumulation time of 24 hours. We consider the Likelihood of LNGRV transit noise causing Harassment to listed species of sea turtles to be Rare, and the Risk level for Harassment to be Low.

Table 7-8 summarizes risk ratings for Operation phase activities for Turtles.

Table 7-8 Risk analysis – operation phase, sea turtles

	Activity Relative to Harassment Criteria	Consequence	Likelihood	Risk
Sea Turtles (leatherback, loggerhead, green and Kemp's ridley sea turtles)	LNGRV transit and mooring	Minor	Rare	Low
	LNGRV weather vaning	Minor	Rare	Low
	Regasification	Minor	Rare	Low

7.3.6 Fish (Atlantic sturgeon)

Predictions of noise from LNGRV transit and mooring show the Harm criterion for fish to be exceeded within a threshold distance of 450 m. Similar to cetaceans and sea turtles it is considered unlikely that fish would stay within the threshold distance for Harm without changing behavior to avoid noise from the LNGRV. As such, we consider the Likelihood of LNGRV transit affecting Atlantic Sturgeon to be Unlikely. The overall risk level to Atlantic Sturgeon from LNGRV transit and mooring is Low for Harassment and Harm.

Weather vaning of the LNGRV is predicted to produce sound levels which will exceed the harm criteria for fish within a threshold distance of 1.8 km. Regasification activities are predicted to exceed the harm criterion for fish within a threshold distance of 750 m. It is considered unlikely that Atlantic Sturgeon would stay within the area of the LNGRV for an accumulation time of 24 hours, hence we consider the Likelihood of LNGRV weather vaning causing Harm to Atlantic Sturgeon to be Unlikely. The overall risk level to Atlantic Sturgeon from LNGRV weather vaning is Low.

We consider the Likelihood of regasification causing Harassment or Harm to Atlantic Sturgeon to be Rare. The overall risk level to Atlantic Sturgeon from regasification is Low for Harassment and Harm.

Table 7-9 summarizes the risk ratings for Port operation activities for Atlantic Sturgeon.

Table 7-9 Risk analysis – operation phase, fish

	Activity Relative to Harm Criteria	Consequence	Likelihood	Risk
Atlantic Sturgeon	LNGRV transit and mooring	Minor	Unlikely	Low
	LNGRV weather vaning	Minor	Unlikely	Low
	Regasification	Minor	Unlikely	Low

8.0 Noise Mitigation Strategies

Impacts to ESA and MMPA species from the proposed Port Ambrose Deepwater Port have been minimized through site selection. During the site selection process, several alternate locations were considered and this site was chosen, in large part, in order to minimize impacts to the environment.

Because impact piling was assessed to have the highest potential for sound generation associated with the proposed Project, a technical feasibility study was conducted and it was determined that suction pilling was a viable alternative to impact piling (Moffatt and Nichol 2014). Although underwater sound measurements of suction pile installations are not available, it is expected that the noise from this method of anchor placement will be negligible relative to existing sounds because the only noise source associated with suction piling is the suction pump (Spence et al. 2007). Since all impulsive type sounds are removed using this approach (CSA Ocean Sciences Inc. 2014), the impact of this activity is considered to be of little or no consequence to protected species transiting the NY Bight.

In addition, operational and behavioral mitigation measures are proposed to further reduce any risk of harm or harassment to protected marine species (Table 8-1). An appropriate combination of these noise mitigation strategies could be adopted as part of a reasonable and prudent approach to minimizing any takes of protected species from the Project. These mitigation measures and other best management practices will ensure that impacts to marine species will be avoided and minimized to the greatest extent practicable (Table 8-1).

Construction activities are identified to have a low risk of causing harm or harassment to marine fauna. Operators will however remain observant for the presence of any marine fauna in the vicinity of these construction activities. If marine fauna suspected to be either an ESA listed species or MMPA protected species are observed in the vicinity of works, construction may need to be put on temporary hold while the marine fauna within the Project area is identified and appropriate action is taken to prevent harassment or harm. In addition, protected species observers (PSOs) and awareness training for construction crews and vessel operators will be implemented.

Operational activities have a low risk of causing harassment or harm to ESA listed species. Noise from LNGRV and Support Vessel movements at Port Ambrose will be of similar magnitude and character to other shipping movements within the New York Bight, and as such the Project vessels should be treated like other vessels in the region without imposing any additional operational modifications beyond what are required on similar shipping vessels. We note that a Seasonal Management Area (SMA) is designated within 20 nautical miles of the entrance to the Port of New York and New Jersey between November 1 and April 30. Vessels over 19.8 m in overall length are restricted to 10 knots during this time for the purpose of protecting whale migratory routes. Any vessels that are associated with the Project (including LNGRVs and support vessels) that enter the SMA will adhere to this regulation.

Table 8-1 Noise mitigation strategies for construction and operational activities

Type of Mitigation	Mitigation Measure	Details
Operational	Use of alternative piling methods	Use of low sound producing piling technique (suction piling).
	Controlled timing of construction program to avoid sound exposure	Construction activities will be scheduled to occur for the minimum practical total duration to reduce the likelihood that protected species will be exposed to noise from construction activities.
	Vessel speed restrictions	• Construction vessels will comply with requirements for vessel strike avoidance. When whales are sighted, a separation distance of 100 yards or greater between the whale and vessels will be maintained (NOAA 2008). When sea turtles or small cetaceans are sighted, an attempt will be made to maintain a distance of 50 yards or greater between the animal and vessels, whenever possible (NOAA 2008). When small cetaceans are sighted while a vessel is underway (e.g., bow-riding), an attempt to remain parallel to the animal's course will be made until the cetacean has left the area. • The required separation distance for North Atlantic right whales of 500 yards (460 m) or greater, in order to reduce disturbance and collision risks, will be followed as per 50 CFR 224.103 (62 FR 6729 and 73 FR 60173). • A Seasonal Management Area (SMA) is designated within 20 nautical miles of the entrance to the Port of New York and New Jersey between November 1 and April 30. • In order to comply with the Right Whale Ship Strike Reduction Rule (50 CFR 224.105), all vessels over 19.8 m in overall length are to be restricted to 10 knots. Vessel speeds during construction activities are slow (less than 10 knots). When vessels are transiting to and from the Project area, speeds of 10 knots or less will be maintained when mother/calf pairs, groups, or large assemblages of cetaceans are observed near an underway vessel, when safety permits (NOAA 2008). The vessels will attempt to route around the animals, maintaining a minimum distance of 100 yards whenever possible. If vessels transit the North Atlantic Right Whale SMA, 10 knot speeds will also be maintained. • In order to avoid vessel strikes during transit and operations, the Early Warning System, Sighting Advisory System, and Mandatory Ship Reporting System notifying mariners of right whale presence will be monitored. • Vessel crews will report sightings of any injured or dead protected species immediately, regardless of whether the injury or death is caused by the Project's vessels. Marine mammals will be reported to the U.S. Stranding Hotline and sea turtles will be reported to NOAA Fisheries Regional Offices. Any injured, dead, or entangled right whales will be immediately reported to the U.S. Coast Guard via VHF Channel 16.

Type of Mitigation	Mitigation Measure	Details
Behavioral	PSOs	• Dedicated personnel will be assigned as PSOs during construction activities. • Safety zones typically include observation and exclusion zones. Exclusion and observation zones for marine mammals and turtles will be determined in consultation with NOAA. In the observation zone, the movement of marine species should be monitored to determine whether they are approaching or entering the exclusion zone. • PSOs operate at all times during daylight hours (dawn to dusk – i.e., from about 30 minutes before sunrise to 30 minutes after sunset) when construction activities are being conducted, unless conditions (fog, rain, darkness) make sea surface observations impossible. If conditions deteriorate during daylight hours such that the sea surface observations are halted, visual observations will resume as soon as conditions permit. • If a marine mammal or sea turtle is observed within the safety zones (as outlined above) the observer will call for the shutdown of the construction operation. The vessel operator will comply with such a call by an on-watch visual observer. Start-up of the construction equipment will continue only after it is determined that a marine mammal or sea turtle has left the safety zone or has not been sighted for 30 minutes.

9.0 Conclusion

An underwater noise impact assessment associated with construction and operation of the proposed Port Ambrose Deepwater Port in the New York Bight has been undertaken.

This assessment was designed to identify, interpret, predict and communicate information concerning potential impacts of underwater sound to protected species. Once identified, these potential impacts were assessed to define the potential risk to species, so where necessary, such risks could be removed or reduced through design, site selection, construction methods or the adoption of reasonable and effective mitigation measures.

The greatest risk of underwater sound to protected species was assessed to be the use of driven pilings as a mooring anchoring system. This source of underwater noise was removed from the project scope and was replaced with the alternative, suction piling.

All other sound sources from the construction and operations phase of the Project are considered to have a Minor impact to species of marine mammals, turtles and fish relative to the “harm” criteria (PTS). The radiation of sound to marine waters during the construction and operations phase of this Project will be within the immediate vicinity of the Project; hence “harassment” (TTS) for all species was ranked as Negligible to Minor. Underwater sound generated from routine maintenance, decommissioning and unplanned events will be similar to those from the construction and operations phase of the Project and as such were not modeled as unique sound sources. Because these activities utilize similar equipment with similar sound sources they are also considered to be Negligible to Minor for marine mammals, sea turtles and protected fish species transiting the project area.

Although species abundance varies by season the likelihood of “harm” (PTS) or “harassment” (TTS) from the Project to individuals or species due to underwater sound is Rare to Unlikely because of the localized and temporary nature of Project construction; transient and seasonal nature of the species moving through the Project area, and the ability of animals to move away from sound sources.

Using the above criteria, the overall risk from underwater sound to protected marine mammals, sea turtles and fish from construction and operational activities of the Project are predicted to have a **low level of risk to all marine fauna**.

In addition, mitigation measures are proposed to further reduce any risk of harm or harassment to protected marine species from underwater sound generated from Project activities.

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Appendix A: NOAA NMFS letter to MARAD and USCG

Appendix A NOAA NMFS letter to MARAD & USCG

DEPARTMENT OF TRANSPORTATION DOCKET OPERATIONS
2013 AUG 21 P 2:10

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
NORTHEAST REGION
55 Great Republic Drive
Gloucester, MA 01930-2276

AUG 12 2013

Tracey L. Ford, Acting Director
Office of Deepwater Ports and
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Maritime Administration
1200 New Jersey Avenue SE, W23-323 (MAR-530)
Washington, DC 20590

C.E. Borland, Acting Chief
Deepwater Ports Standards Division
United States Coast Guard
2100 Second Street, SW
Washington, DC 20593-0001

Re: Liberty Natural Gas, LLC Deepwater Port (USCG-2013-0363)

Dear Mr. Borland and Ms. Ford,

This is in response to your letter dated August 8, 2013, regarding Liberty Natural Gas, LLC's, proposal to own, construct, and operate a deepwater port (Port Ambrose) in the Atlantic Ocean, approximately 17 nautical miles southeast of Jones Beach, New York; approximately 24 nautical miles east of Long Branch, New Jersey; and approximately 27 nautical miles from the entrance to New York Harbor. You have requested information on the presence of species listed by NOAA's National Marine Fisheries Service (NMFS) in the project area.

The following Endangered Species Act (ESA) listed species under NOAA's NMFS are likely to occur in the proposed project area:

Species	***Status***
Gulf of Maine Distinct Population Segment (DPS) of Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*)	Threatened
New York Bight DPS of Atlantic sturgeon	Endangered
Chesapeake Bay DPS of Atlantic sturgeon	Endangered
Carolina DPS of Atlantic sturgeon	Endangered
South Atlantic DPS of Atlantic sturgeon	Endangered
Northwest Atlantic Ocean DPS of loggerhead sea turtle (*Caretta caretta*)	Threatened
Kemp's ridley sea turtle (*Lepidochelys kempi*)	Endangered
Green sea turtle (*Chelonia mydas*)	Endangered

North Atlantic Right Whales (*Eubalaena glacialis*)	Endangered
Humpback whale (*Megaptera novaeangliae*)	Endangered
Fin whale (*Balaenoptera physalus*)	Endangered

Listed species of Atlantic sturgeon may be present in the project area year round, while listed species of sea turtles are known to be present in the waters of New York and New Jersey from May through November, with the highest concentration of sea turtles present from June to October. The federally endangered North Atlantic right, humpback, and fin whales, are seasonally present in the waters off New York and New Jersey. These species of whales use the nearshore, coastal waters of the Atlantic Ocean as a migration route to and from calving and foraging grounds. Humpback and fin whales primarily occur in the waters of New York and New Jersey during the spring, summer and fall months, while the North Atlantic right whale primarily occur in these waters from November 1 through April 30, although transient right whales can be present outside of this time frame. Additionally, during the November 1 through April 30 timeframe, a seasonal management area (SMA) has been designated for North Atlantic right whales within a 20-nautical mile radius (as measured seaward from the COLREGS lines) of the entrance to the Ports of New York and New Jersey (located at 40°29'42.2"N and 073°55'57.6"W). Vessels 65 feet or greater in overall length transiting through the SMA at this time are restricted to 10 knots or less to protect right whales in their migratory routes.[1] As the proposed project will cross waters of the SMA, please be aware of these regulations should your proposed project occur during the months of November 1 through April 30.

Conclusion

As listed species are likely to be present in the action area of this project, a consultation, pursuant to Section 7 of the Endangered Species Act (ESA) of 1973, may be necessary. As you may know, any discretionary federal action, such as the approval or funding of a project by a Federal agency, that may affect a listed species must undergo consultation pursuant to Section 7 of the Endangered Species Act (ESA) of 1973, as amended. If the proposed project has the potential to affect listed species and it is being approved, permitted or funded by a Federal agency, the lead Federal agency, or their designated non-Federal representative, is responsible for determining whether the proposed action is likely to affect this species. The Federal agency would submit their determination along with justification for their determination and a request for concurrence, to the attention of the Endangered Species Coordinator, NMFS Northeast Regional Office, Protected Resources Division, 55 Great Republic Drive, Gloucester, MA 01930. After reviewing this information, NMFS would then be able to conduct a consultation under Section 7 of the

[1] For more information on this SMA, see http://www.nmfs.noaa.gov/pr/pdfs/shipstrike/compliance_guide.pdf

ESA. Should you have any questions about these comments or about the Section 7 consultation process in general, please contact Danielle Palmer (978-282-8468; Danielle.Palmer@noaa.gov).

Sincerely,

Mark Murray-Brown

for Mary A. Colligan
Assistant Regional Administrator
for Protected Resources

EC: Palmer, NMFS/PRD
Rusanowsky, Boelke NMFS/HCD

File Code: Sec 7 technical assistance 2013– Port Ambrose LNG

Appendix B: Impact Piling: Relationship Between Noise Metrics

Appendix B: Impact Piling: Relationship Between Noise Metrics

Where modelling results are not reported using a particular noise metric it is possible to approximate noise metrics based upon the relationship between metrics from results of measurements of similar sound sources. Table B-1 below shows the relationship between dB_{rms} and dB_{peak} using previously collected data for piling driving.

AECOM undertook underwater noise measurements of impact piling similar to that proposed for Port Ambrose for the Adelaide Desalination project in Adelaide, South Australia in 2010. Impact piling of piles of comparable size to those proposed for Port Ambrose was undertaken in seawater in the Gulf St. Vincent at a depth of approximately 20 m. Table B-1 shows the signal recorded by the hydrophone located 2,000 m from an impact piling source, annotated with the peak and rms levels. The left graph of Figure B-1 shows the piling signal over several impacts, with the right graph showing the signal for a single impact (also shown on the left graph).

Figure B-1 Piling noise at 2,000m from Adelaide Desalination Plant impact piling

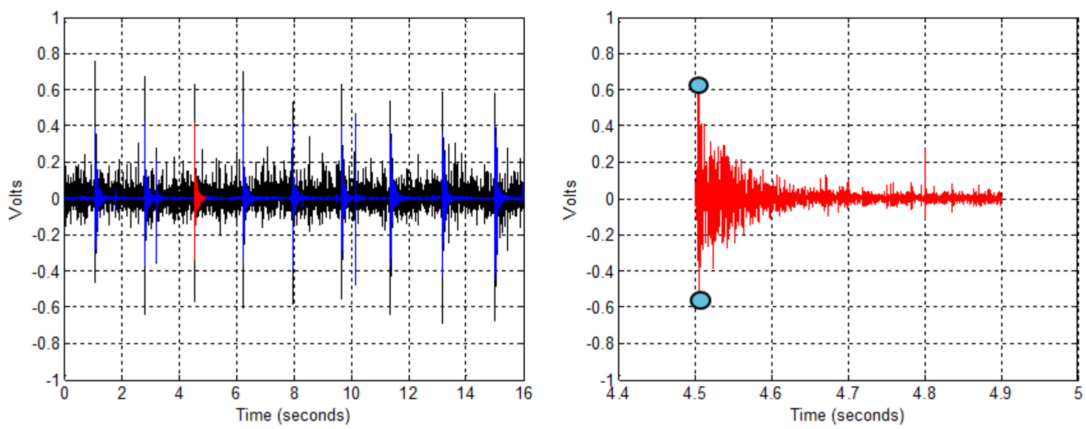

Table B-1 Noise metrics for impact piling at Adelaide Desalination Plant

Noise metric	Measured Level at 2 km from Piling	Relative Difference to Average Sound Pressure Level dB_{rms}
Average sound pressure level (dB_{rms})	141 dB re 1 µPa	N/A
Peak SPL (dB_{peak})	162 dB re 1 µPa	+21 dB
Peak-to-peak SPL	168 dB re 1 µPa	+27 dB

The measured noise metrics for impact piling and the relationship between average sound pressure level (dB_{rms}) and Peak SPL (dB_{peak}) is shown in Table B-1. For noise from impact piling sources in similar conditions (and depths), the measured values of 141 dB re 1 µPa for average sound pressure level (dB_{rms}) was measured, and the Peak SPL (dB_{peak}) was measured to be 162 dB re 1 µPa. In cases where dB_{peak} levels have not been modelled, an approximation of peak levels can therefore be made by adding a +21 dB adjustment to dB_{rms} average sound pressure levels.

Appendix C: Impact Piling Alternative

Appendix C: Impact Piling Alternative

Low frequency cetaceans and piling driving

As described in detail in Section 4, there are three whale species listed as endangered under the ESA that could potentially transit the Project area that are classified as LF cetaceans: fin whales, humpback whales, and the North Atlantic right whale.

Predicted noise levels from impact piling (if needed) suggest the TTS criterion to be exceeded for low frequency cetaceans within 65 km of the piling source, and PTS threshold to be exceeded within 13 km of piling (Table C-1). If impact piling were to occur, it is anticipated that any impacts would be limited to individuals that aretransiting the Project area while impact piling is occuring.. Considering the size of the threshold distances, the short duration of impact piling (i.e. approximately 2.5 hours of sound generation per pile) and other qualitative factors such as potential behavioural avoidance to noise and the transient nature of animals, we consider the Likelihood rating of impact piling affecting low frequency cetaceans to be Unlikely for TTS and Rare for PTS and the consequence to the species to be Minor. The overall risk level to low frequency cetaceans is therefore Low for both PTS and TTS occurrence.

Mid frequency cetaceans and pile driving

The most likely mid frequency cetaceans to occur in the vicinity of the Project are bottlenose dolphins and common dolphins, which are relatively abundant during the construction period.

Predicted noise levels from impact piling (to be used, only if needed) suggest the TTS criterion to be exceeded for mid frequency cetaceans within 9.5 km of the piling source, and PTS threshold to be exceeded within 1.2 km of piling (Table C-1). Considering the size of the threshold distances, the short duration of impact piling (i.e. approximately 2.5 hours sound generation per pile) and other qualitative factors such as potential behavioural avoidance to noise, we consider the Likelihood rating of impact piling affecting mid frequency cetaceans to be Likely for TTS and Unlikely for PTS with the overall consequence to the species being Minor. The overall risk level to mid frequency cetaceans from piling driving is Low for PTS and Medium for TTS occurrence.

High frequency cetaceans and pile driving

The only species classified as a high frequency cetacean occurring in the vicinity of the Project is the Harbor Porpoise. Harbor porpoises are typically present at the spring and autumn months, corresponding to the start and end of the construction period.

Predicted noise levels from impact piling suggest the TTS criterion to be exceeded for high frequency cetaceans within 95 km of the piling source, and PTS threshold to be exceeded within 23 km of piling (Table C-1). The size of the threshold distances is quite large. However, after considering other qualitative factors such as the short duration of piling activities which also will likely occur outside of Harbor Porpoise season, we consider the Likelihood rating of impact piling affecting high frequency cetaceans to be Likely for TTS and Unlikely for PTS threshold distances. The overall risk level to high frequency cetaceans is Low for PTS and Medium for TTS occurrence.

Table C-1 Summary of pile driving threshold distances for whales, dolphins and porpoises

Activity	Month	LF Cetaceans (Whales)		MF Cetaceans (Dolphins)		HF Cetaceans (Porpoises)	
		PTS Threshold [m]	TTS Threshold [m]	PTS Threshold [m]	TTS Threshold [m]	PTS Threshold [m]	TTS Threshold [m]
Impact Piling	May	12,200	64,800	1130	9,470	22,700	94,700
	Oct	9,100	27,900	1040	7,290	14,900	37,200

Seals

Seals are only likely to inhabit the Project area at the beginning and/or end of the construction phase. Harbor, Gray and Harp seals are typically present in the New York Bight in autumn, winter and spring.

Predicted noise levels from impact piling suggest the TTS criterion to be exceeded for seals within 38 km of the piling source, and PTS threshold to be exceeded within 7 km of piling (Table C-2). Piling will occur when numbers are low, and so it is anticipated that noise impacts will be limited to individuals which are transiting the Project area mostly out of season. Also considering the large size of the threshold distances and the short duration of piling activities we consider the Likelihood rating of impact piling affecting seals to be Unlikely for TTS and Rare for PTS with the consequence to the species being Minor. The overall risk level to seals from pile driving is Low for both PTS and TTS occurrence.

Sea turtles

Noise predictions for impact piling underwater noise show the Harassment criterion is exceeded for animals within 1.1 km of piling. (Table C-2). Construction is scheduled during the months of May through October, which is the period with the highest numbers of turtles present in the Project area, and it is noted that turtles will not transit the Project area outside of these months. Piling will only occur for approximately 2.5 hours per pile (if necessary) out of the seven months turtles are present in the New York Bight region, and as such piling noise impacts on turtles will be restricted to this narrow time frame. We have assessed the Likelihood of impact piling causing Harassment to ESA listed turtles as Likely, hence the overall risk level to ESA listed sea turtles from impact piling associated with the Project is Medium for Harassment.

Fish (Atlantic Sturgeon)

Atlantic sturgeon exposed to high levels of underwater noise such as piling driving could experience tissue damage or other physical injury, potentially leading to mortality. Elevated underwater noise levels are anticipated to have a Moderate consequence on Atlantic sturgeon where the Harm criterion is exceeded. The Harm criterion is exceeded within a threshold distance of 13 km from impact piling (Table C-2). Atlantic Sturgeon could transit the Project area year round, and so may potentially be present during impact piling. However, the short duration of piling and transient nature of the fishes movements will limit the potential impact on the species. The Likelihood rating of impact piling affecting Atlantic Sturgeon is therefore considered Unlikely for Harm and so the overall risk level to Atlantic Sturgeon from impact piling associated with the Project is is calculated as Medium.

Table C-2 Summary of pile driving threshold distances for seals, turtles and Atlantic sturgeon

Activity	Month	Seals		Sea Turtles		Fish (Atlantic Sturgeon)	
		PTS Threshold [m]	TTS Threshold [m]	Harm Threshold [m]	Harassment Threshold [m]	Harm Threshold [m]	Harassment Threshold [m]
Impact Piling	May	6,550	3,7200	NA	1,100	12,700	NA
	Oct	5,350	20,700		1,000	9,470	

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Appendix N

Independent Risk Assessment

FINAL REPORT – REVISION 3

INDEPENDENT RISK ASSESSMENT FOR PORT AMBROSE LNG DEEPWATER PORT PHASE I

PREPARED FOR:

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AUGUST 19, 2014

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Acronyms & Abbreviations

AIS	Automatic Identification System
ALARP	As Low as Reasonably Practicable
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ATBA	Area-to-be-Avoided Zone
CFD	Computational Fluid Dynamics
CFR	Code of Federal Regulations
COLREG	International Convention for the Prevention of Collisions at Sea
DEGADIS	DEnse GAs DISpersion model
DOE	US Department of Energy
DOT	US Department of Transportation
DWP	Deepwater Port
DWPA	Deepwater Port Act
EIS	Environmental Impact Statement
ft	Feet
FEED	Front End Engineering Design
FERC	Federal Energy Regulatory Commission
CG-OES-2	USCG Office of Vessel and Facility Operating Standards
CG-OES-4	USCG Deepwater Ports Standards Division
HAZID	Hazard Identification
HIPPS	High Integrity Pressure Protection System
IGC	International Gas Code
IGIF	Inert Gas Injection Facility
IMO	International Maritime Organization
IRA	Independent Risk Assessment
ISM Code	International Safety Management Code
kg	kilogram
km	kilometer
kts	Knots
kW	kilowatt
LFL	Lower Flammability Limit
LNG	Liquefied Natural Gas
LNGC	Liquefied Natural Gas Carrier
LNGRV	Liquefied Natural Gas Regasification Vessel
m	meter
MARAD	Maritime Administration
min	minute
Mmscfd	million standard cubic feet per day
MTSA	Maritime Transportation Security Act
NAA	No Anchoring Area
NEPA	National Environmental Policy Act
NG	Natural Gas
nm	Nautical Mile
NOAA	National Oceanographic & Atmospheric Administration

PLEM	Pipeline End Manifold
RACA	Risk Assessment and Consequence Analysis
REM	Riser End Manifold
RS	Reynolds Stress
s	Second
SIGTTO	Society of International Gas Tanker and Terminal Operators
SOLAS	International Convention for the Safety of Life at Sea
SPM	Single-point mooring
STL	Submerged turret loading
TSS	Traffic Separation Scheme
UFL	Upper Flammable Limit
UNCLASS	Unclassified
USC	United States Code
USCG	U.S. Coast Guard
VTS	Vessel Traffic Service

Executive Summary

A. Background

On September 28, 2012, the U.S. Coast Guard (USCG) and U.S. Maritime Administration (MARAD) received an application from Liberty Natural Gas, LLC, for all Federal authorizations required for a license to own, construct and operate a Deepwater Port (DWP), known as Port Ambrose (Port Ambrose, or the Project) in the New York Bight (offshore of New York and New Jersey). Port Ambrose is designed solely for the delivery of natural gas. Liberty LNG will focus its deliveries during peak winter and summer months to provide additional supplies of natural gas to New York during periods of peak demand.

This document is a stand-alone technical report on the potential risks to the public from the proposed Port Ambrose project based on a large-scale release of Liquefied Natural Gas (LNG). The primary objective of this Independent Risk Assessment (IRA) is to assess impacts to humans and property not associated with the DWP from an event(s) that compromises LNG containment.

Port Ambrose is similar in design to two currently operating offshore LNG ports near Boston, Massachusetts and an approved port near Tampa, Florida. The Port Ambrose project would consist of two Submerged Turret Loading™ buoy (STL Buoy) systems (collectively, the DWP) in Federal waters approximately 16.5 nautical miles (nm) (30.56 kilometers (km)) southeast of Jones Beach, New York, and approximately 26.9 nm (49.63 km) from the entrance of New York Harbor (Figure 1-1), in a water depth of approximately 103 feet (ft) (31.39 meters (m)).

LNG would be delivered from purpose-built LNG regasification vessels (LNGRVs), vaporized on site and delivered through the STL buoys, flexible riser/umbilical, subsea manifold and lateral pipelines to a buried 19 nm (35 km) subsea mainline connecting to the existing Transco Lower New York Bay Lateral in New York State waters approximately 2.2 nm (4.1 km) south of Long Beach, New York and 13 nm (57 km) east of Sandy Hook, New Jersey. The buoys will be lowered to rest on a landing pad when not in use and would also include a pile-anchored mooring array.

The 145,000 cubic meter, membrane type LNGRVs would have onboard closed-loop vaporization and metering and odorant capability. Each vessel will have three vaporization units capable of a maximum send-out of 750 million standard cubic feet per day (MMscfd) (maximum pipeline system flow rate is 660 MMscfd with two buoys) with annual average expected to be 400 MMscfd. The LNGRVs have been designed to utilize a ballast water cooling system that will entirely re-circulate onboard the vessel during Port operations, eliminating vessel discharges associated with regasification while at the Port.

Deliveries through Port Ambrose would be focused during peak demand winter and summer months. The Port will receive up to 45 LNGRVs per year. As proposed, the LNGRVs would access the port inbound from the Hudson Canyon to Ambrose Traffic Lane and depart via the Ambrose to Nantucket Traffic Lane, Figure B.

If approved, the majority of the port and pipeline construction and installation are proposed to occur in 2015, with commissioning in December 2015.

B. Study Process

The deepwater port (DWP) license application review process includes an analysis of the proposed project's impacts on public safety based on a large scale release of LNG. The reference to "public" refers to human and property not associated with the DWP. The scope of the IRA does not include the natural gas sub-sea pipeline or any additional onshore gas pipeline or facilities.

As part of this analysis, a project's specific risk assessment is comprised of two parts:

- Phase I is an independent risk assessment (IRA) that evaluates potential maximum hazards of Liquefied Natural Gas (LNG) releases from credible scenarios (identification of the bounding or worst-credible consequences), as required by 33 CFR Part 148.105(y), and is an input to the Environmental Impact Statement (EIS) process.
- Phase II is a risk assessment (RA) that examines the range of scenarios that could result in an LNG release and evaluates proposed strategies to reduce the risk, providing input to Operations/Security (OPS/SEC) manuals required by 46 CFR 150.10 and potentially incorporating safety and security measures into the Marine Administrator's Record of Decision (ROD), as delegated by the Secretary of Transportation.

This report is limited to the Phase I IRA and involved six steps.

Table A: IRA Process

Step	Description
1. DWP Area Characterization	The DWP application was reviewed and additional data was gathered and analyzed about the port environment.
2. HAZID	Input was received from USCG, Sandia National Laboratories, federal, state and local emergency responders, law enforcement intelligence, pilots and the applicant to identify accidental and intentional scenarios.
3. Scenario Development	The HAZID scenarios were further analyzed to determine credible and bounding scenarios.
4. Vessel Collision and Frequency Analysis	Vessel traffic in the areas was analyzed to determine frequency of potential collisions.
5. Consequence Analysis	The impacts of the bounding cases were analyzed using Computational Fluid Dynamics (CFD) modeling to evaluate LNG spill and pooling and flammable vapor dispersion hazards. A solid flame model was used to evaluate the thermal radiation hazards.
6. Results and Conclusions	The analysis results were assessed and are presented in this report.

The conclusions of this IRA are presented as the hazard zones for thermal radiation and flammable vapor cloud dispersion for the accidental and intentional release scenarios evaluated. The hazard zones have been presented as graphical overlays on the nautical charts for the proposed Port Ambrose DWP project location. The results of the study are presented without passing judgment on the merits of the applicant's proposed project.

While the study evaluated the potential impacts to the public and surrounding infrastructure, it did not attempt to predict the number of estimated fatalities or injuries from these events. Also, the study was done without considering any mitigation measures that could be implemented to reduce the risk of accidental or intentional release of LNG from this proposed project. These considerations may be subject to further review outside of the scope of this study. Mitigation measure to reduce the risk associated with an LNG release will be discussed in the Phase II Risk Assessment.

The proposed Port Ambrose DWP falls within the proposed area of interest for the wind energy project(s) proposed for offshore New York as described in the Bureau of Ocean Energy Management's Call for Information of May 28, 2014 (79 FR 30645). The risk assessment will take this proposal into account; however, because of the lack of specific wind project details, this report is necessarily constrained in its ability to provide an analysis of the navigational safety risks that operation of the deepwater port may have on a future wind farm siting and operation. While it would be inappropriate for this report to purport to establish specific setbacks between the deepwater port, vessels operating in the area, and the wind farm, this report does provide information on LNG spill consequences which will help inform any future offshore wind energy project proponent on future siting of wind turbines. To the extent practicable, in the absence of a detailed wind farm application, the Phase II portion of the IRA will examine navigational safety concerns and consider measures that may serve to mitigate potential risks of both facilities operating in the same geographic area.[1]

C. Results

C.1 Scenarios Selected

The scope of the HAZard IDentification (HAZID; Step 3, Table A) was the identification of "credible" scenarios for accidental and intentional events involving all parts of the proposed project under the jurisdiction of the USCG. Credible scenarios as defined in the HAZID process do not necessarily represent scenarios that are high risk. They are possible intentional and accidental scenarios identified through a multidisciplinary team evaluation of the project. The scenarios are identified regardless of likelihood and are used in the Phase I IRA for bounding the consequences of concern.

C.2 Consequence Modeling Results

Thermal radiation hazard distances from a pool fire were estimated to two different thermal heat flux levels:

- 37.5 kW/m^2: Damage to process equipment and storage tanks[2] for unprotected exposures based on an average 10-minute exposure duration, as well immediate fatalities

[1] This IRA does not establish enforceable requirements on any potential future wind farm operator. The BOEM may consider this information as it determines what, if any, operational restrictions may need to be imposed on a proposed wind farm. Pursuant to the Memorandum of Agreement between (then) BOEMRE and the USCG (dtd 27Jul2011), the USCG will assist BOEM in assessing the navigational risks that may be posed by renewable energy development, For additional information, see Navigation and Vessel Information Circular, 02-2007, "Guidance on the Coast Guard's Roles & Responsibilities for Offshore Renewable Energy Installations (OREI)."

[2] Barry, Thomas, *Risk-Informed Performance-based Industrial Fire Protection* (Knoxville, TN: Tennessee Valley Publishing, 2002).

- 5 kW/m^2: Permissible level for emergency operations lasting several minutes with appropriate clothing based on an average 10-minute exposure duration[3] and onset of second degree burns based on an average 40-second exposed duration[4]

The maximum thermal radiation hazard and flammable vapor dispersion distances predicted for the intentional and vessel collision scenarios are listed in Table B. In this IRA, it is assumed that all spills originate at the LNGRV, with all hazard distances measured from the center of the LNG pool.

The flammable vapor dispersion hazard distance is determined as the maximum downwind distance to the Lower Flammability Limit (LFL). The flammable vapor cloud dispersion simulations were performed using FLACS, a commercial Computational Fluid Dynamics (CFD) code. Given the right environmental conditions, the maximum distances could occur in the direction of prevailing wind at the time of release from the LNG release source. The weather data for the Port Ambrose site is detailed in Section 3.5. The specific modeling parameters for the consequence analysis are detailed in Section 7.4.

All distances in Table B are measured from the center of the pool, which is the source of the LNG release. Note that the maximum pool diameters are different for the pool fire and vapor cloud dispersion cases. This is due to different boundary conditions (e.g., fire vs. no fire) as well as the different model applied to the analysis (e.g., equilibrium mass balance for pool fire vs. dynamic CFD model for vapor dispersion).

Table B: Summary Risk Analysis Consequences for Bounding Scenarios

Result	**Scenario 1 (Intentional)**	**Scenario 2 (Intentional)**	**Scenario 6 (Collision)**
Breach Size, m^2	16	12	23.1
Number of Tanks	1	2	1
Total Capacity of Impacted Tank(s), m^3	41,429	82,857	41,429
Release Quantity, m^3	29,000	58,000	29,000
Pool Fire Maximum Distance to Endpoint (meters)			
Pool Diameter, m	579	709	696
Thermal Radiation Endpoint > 37.5kW/m^2	970	1,110	1,090
Thermal Radiation Endpoint > 5 kW/m^2	2,270	2,640	2,600
Flammable Vapor Cloud Dispersion (No Ignition)			
Maximum Pool Diameter (m)	533	556	541
Distance to LFL, m	2,800	3,550	2,750

These scenarios represent the bounding thermal radiation hazards for the intentional and vessel collision scenarios. A pool fire at either Buoy #1 or Buoy #2 would not impact the other buoy location from a sustained fire at the 37.5 kW/m^2 and 5 kW/ m^2 radiation levels. Additionally, the safety fairway is not impacted at these radiation levels.

[3] Ibid.
[4] Federal Emergency Management Agency, *Handbook of Chemical Hazard Analysis Procedures*, (Washington, DC: FEMA, 1989).

As compared to the pool fire consequence, where the thermal radiation hazard extends radially from the pool fire center, the flammable vapor dispersion hazard will extend as a cloud dispersing in the downwind direction of the prevailing wind. .

The intentional scenario (Scenario 2) results in the greatest distance to LFL, and an intentional incident at either buoy could potentially impact the other buoy location. Assuming the wind direction was toward a second LNGRV at the adjacent buoy (see Figure 3-5). However, given a dispersion duration of over 20 minutes to the other buoy location, the other LNGRV has an emergency buoy disconnect that can shutdown regasification and disconnect the LNGRV in 15 minutes.

In addition to impacting the other buoy, the dispersion distance to LFL from Scenario 2 (from Buoy #2) could also impact Ambrose to Nantucket lane, depending on the wind direction (see Figure 3-5) at the time of release. As discussed above, a similar dispersion time of over 20 minutes is predicted for the cloud to reach the shipping lane.

C.3 Frequency of Events

The total frequency of a collision with an LNGRV at the DWP was calculated for two vessel types: 1) vessels in the established Ambrose to Nantucket lane and the Hudson Canyon to Ambrose lane, and 2) vessels randomly passing the DWP location. This calculation utilized vessel traffic from the Automatic Identification System (AIS) dataset provided for this project by the USCG R&D Center, and only included those vessels with the potential to breach the inner hull of the LNGRV (resulting in a release of LNG from containment) in a collision.

Due to the distance between the DWP and the vessels in the two adjacent traffic lanes, the likelihood of a powered and drifting collision from vessels in these defined routes and the LNGRV was unlikely. In addition to vessels in the defined fairway, vessels of sufficient displacement and speed were identified that passed near the DWP. Using the collision frequency calculation for randomly distributed vessels, the likelihood for these vessels colliding with the DWP was calculated. However, given the small number of random vessels and the size of the LNGRV, the likelihood is also unlikely.

The collision frequency for the proposed DWP considering both vessels in the two adjacent traffic lanes and randomly distributed around the DWP is shown in Table C.

Table C: Frequency of Vessel Collisions for Proposed DWP

TRAFFIC LOCATION	ANNUAL FREQUENCY OF COLLISION (COLLISION PER YEAR)	COLLISION ESTIMATED PERIOD (YEARS PER COLLISION)
Ambrose to Nantucket Lane	2.13×10^{-5}	1 collision every 47,000 years
Hudson Canyon to Ambrose Lane	7.98×10^{-9}	1 collision every 125,000 years
Randomly Distributed	1.67×10^{-8}	1 collision every 60,000 years
TOTAL	$\mathbf{2.13 \times 10^{-5}}$	**1 collision every 47,000 years**

1.0 Project Overview

The Secretary of Transportation is authorized under the Deepwater Port Act[5] to issue licenses for the ownership, construction and operation of deepwater ports.[6] This includes liquefied natural gas (LNG) facilities. The Secretary delegated authority for processing license applications to the U.S. Coast Guard (USCG) and the U.S. Maritime Administration (MARAD).

To enable a more efficient application review process, the USCG established procedures for license applicants to hire third-party consultants, under direction of the USCG, to conduct statutorily required analyses (e.g., Environmental Impact Statements (EISs) and Independent Risk Assessments (IRAs))[7].

1.1 Introduction

On September 28, 2012, the USCG and MARAD received an application from Liberty Natural Gas, LLC, for all Federal authorizations required for a license to own, construct, and operate a deepwater port (DWP) called Port Ambrose. The USCG deemed the application complete subsequent to a review as required by the Deepwater Port Act (DWPA).

1.2 The Independent Risk Assessment (IRA)

This IRA is submitted by AcuTech Consulting Group (AcuTech) to the USCG for the proposed Port Ambrose, LNG DWP Project. This IRA provides the necessary data for the public safety section of the EIS being developed for the Project. AcuTech is the lead contractor for the IRA, responsible for the development of a stand-alone technical report on the potential risks to the public from potential large-scale release(s) of LNG or natural gas. Under contract to AcuTech, GexCon US (GexCon) conducted the modeling for liquid spills, fire, and vapor dispersion for the LNG release scenarios defined in the IRA. This included use of a three-dimensional computational fluid dynamics (CFD) model for the flammable dispersion consequences.

AcuTech is a global company providing consulting, training, and technologies to the public and private sectors to identify, evaluate, and manage risks in order to continually improve safety, security, health, environmental, and operational performance. AcuTech has expertise in LNG operations, security, process safety, offshore hazardous materials installation operations, risk assessment, fire protection, and homeland security for critical infrastructure.

GexCon US has vast experience performing LNG hazard analyses and probabilistic risk assessments for LNG plants. Staff expertise includes consequence modeling for LNG vapor cloud dispersion, thermal radiation from LNG pool fires and vapor cloud explosion scenarios. Their CFD model, FLACS, enables LNG pool spreading and vapor cloud dispersion in one unified environment.

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[5] Deepwater Port Act (DWPA) of 1974 as amended by the Maritime Transportation Security Act of 2002 (MTSA); 33 United States Code 1501, *et seq* and Coast Guard and Marine Transportation Act of 2012

[6] The term "deepwater port" refers to any fixed or floating manmade structures other than a vessel, or any group of such structures, located beyond the territorial sea and of the coast if the United States, and intended for the loading or unloading and further handling of oil for transportation, except as excluded in 33 U.S.C. 1522.

[7] *Guidance on Assessing the Risks and Consequences of a Liquefied Natural Gas (LNG) Deepwater Port*, U.S. Department of Homeland Security, U.S. Coast Guard, October 2010.

The purpose of this work is to develop a stand-alone technical report on the potential risks to the public from the proposed Port Ambrose DWP based on a large scale release of LNG. The reference to "public" refers to human and property not associated with the DWP.

The scope of the IRA does not include the natural gas sub-sea pipeline or any additional onshore gas pipeline or facilities.

The assessment is not a full probabilistic risk assessment which estimates the cumulative frequency of all expected losses over the life of the DWP facilities, but instead is a deterministic study of the most significant credible loss scenarios that represent the maximum expected impacts from accidental and intentional scenarios developed and defined as part of the IRA. As such, the study provides representative scenarios for consideration and derives the most significant consequences (defined as the bounding intentional and accidental scenarios) for presentation of the maximum expected impacts to public safety.

The USCG Office of Operating and Environmental Standards, Deepwater Ports Standards Division (CG-OES-4) directed the scope, content, and quality of the report. The applicant, Liberty Natural Gas, LLC, had no technical direction of the work conducted under this contract, and was not able to review the work product before its release to the public. The applicant did, however present an overview of the Port Ambrose project to the IRA team as part of the HAZard IDentification (HAZID), and answered additional questions as requested.

1.3 Proposed Port Ambrose Deepwater Port

Liberty Natural Gas, LLC is proposing to construct, own, and operate a DWP offshore of New York and New Jersey. Port Ambrose is similar in design to the licensed and commissioned Northeast Gateway and Neptune DWPs offshore Boston, Massachusetts, and to Port Dolphin DWP, located offshore Tampa, Florida, which has received a license from MARAD, but which has not started construction. The unloading portion of the proposed Port Ambrose DWP, would be located in federal waters approximately 16.5 nm (30.56 km) off Jones Beach, New York, approximately 26.9 nm (49.63 km) from the entrance to New York Harbor, in a water depth of approximately 103 ft (31.39 m). The location of the offshore components of the project is illustrated in Figure 1-1.

As shown in Figure 1-1, the DWP would be located between designated shipping fairways which would allow LNG carriers to approach and depart without interfering with existing traffic.

The DWP would consist of two buoys 1.65 nm apart. LNG would be delivered from purpose-built LNG regasification vessels (LNGRVs), vaporized on site and delivered through the Submerged Turret Loading (STL) buoys, flexible riser/umbilical, subsea manifold and lateral pipelines to a buried 19 nm (35 km) subsea mainline connecting to the existing Transco Lower New York Bay Lateral in New York State waters, approximately 2.2 nm (4.1 km) south of Long Beach, New York and 13 nm (57 km) east of Sandy Hook, New Jersey. The buoys would be lowered to rest on a submerged landing pad when not in use and would also include a pile-anchored mooring array.

The coordinates of the proposed buoys of the DWP are illustrated in Figure 1-2.

Figure 1-1: Port Ambrose Proposed Project Location

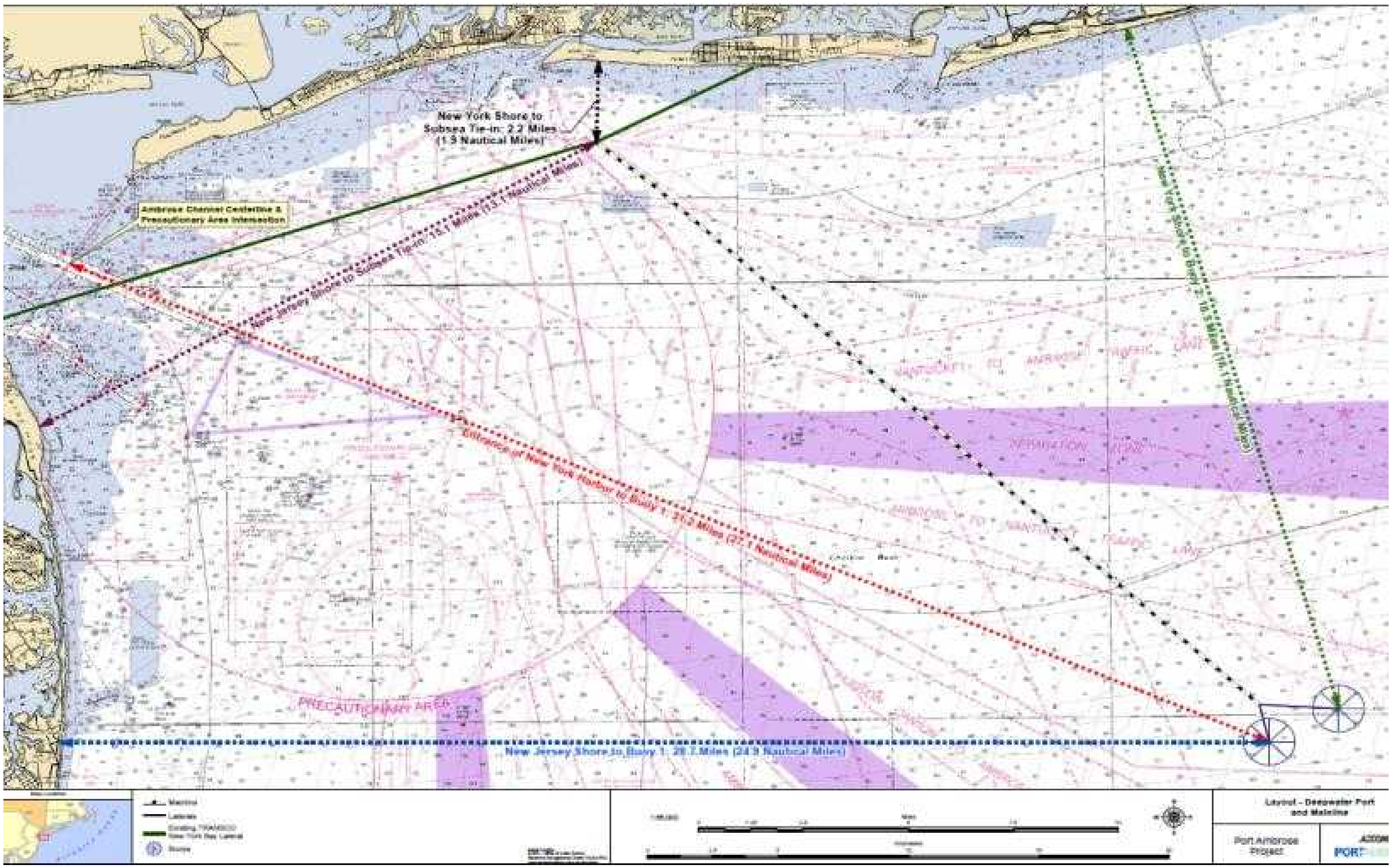
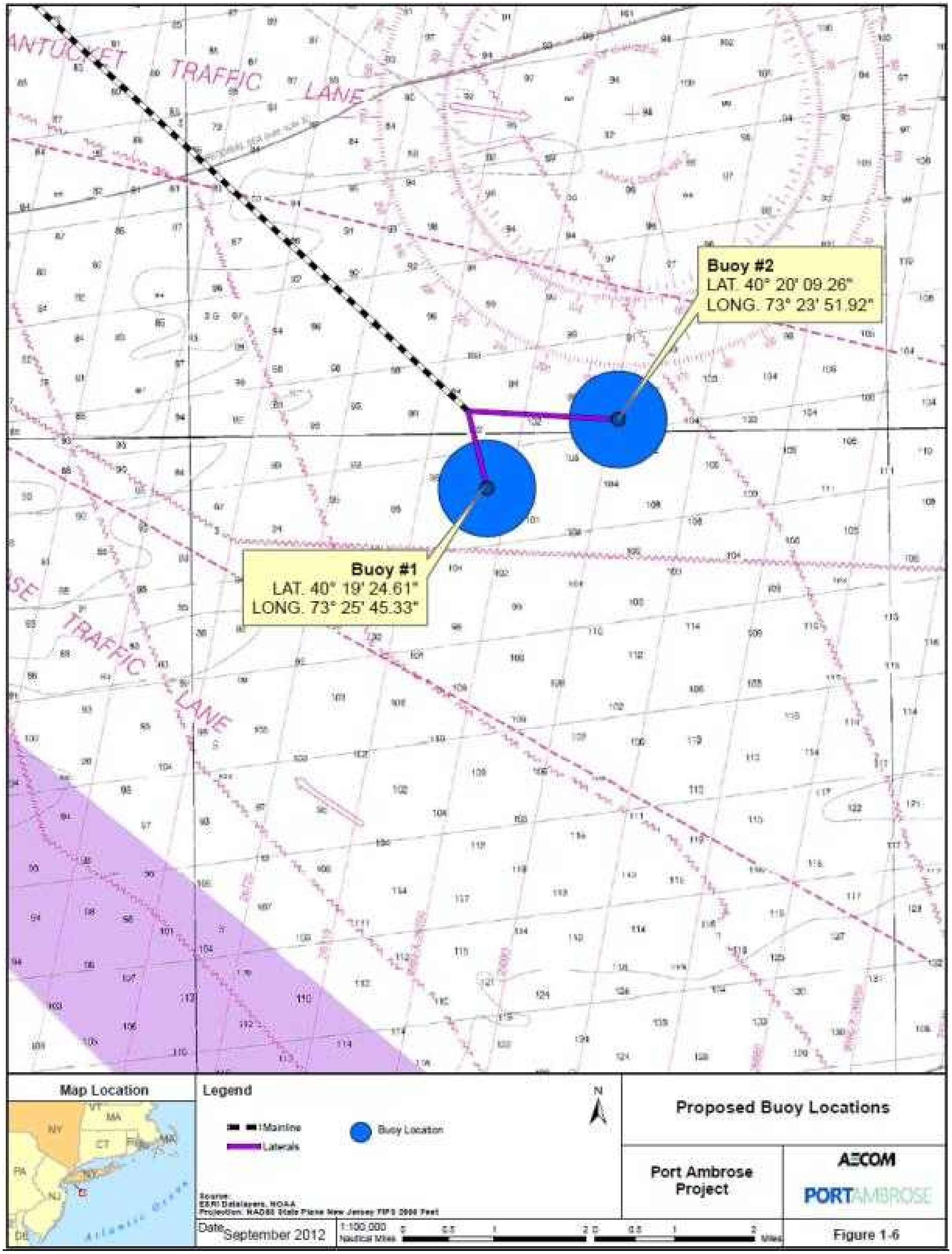


Figure 1-2: Unloading Buoy Coordinates



As part of the DWP, Port Ambrose would be capable of mooring Shuttle and Regasification Vessels (LNGRVs), as depicted in Figure 1-3. The LNGRVs are standard LNG tankers that have been built or modified to connect with the STL Buoys and delivery of natural gas to ports like the proposed Port Ambrose Project. The LNGRVs will be capable of transporting approximately 3.2 billion cubic feet (bcf) of natural gas condensed to approximately 5.1 million cubic feet (MMcf or 145,000 m^3) of LNG.

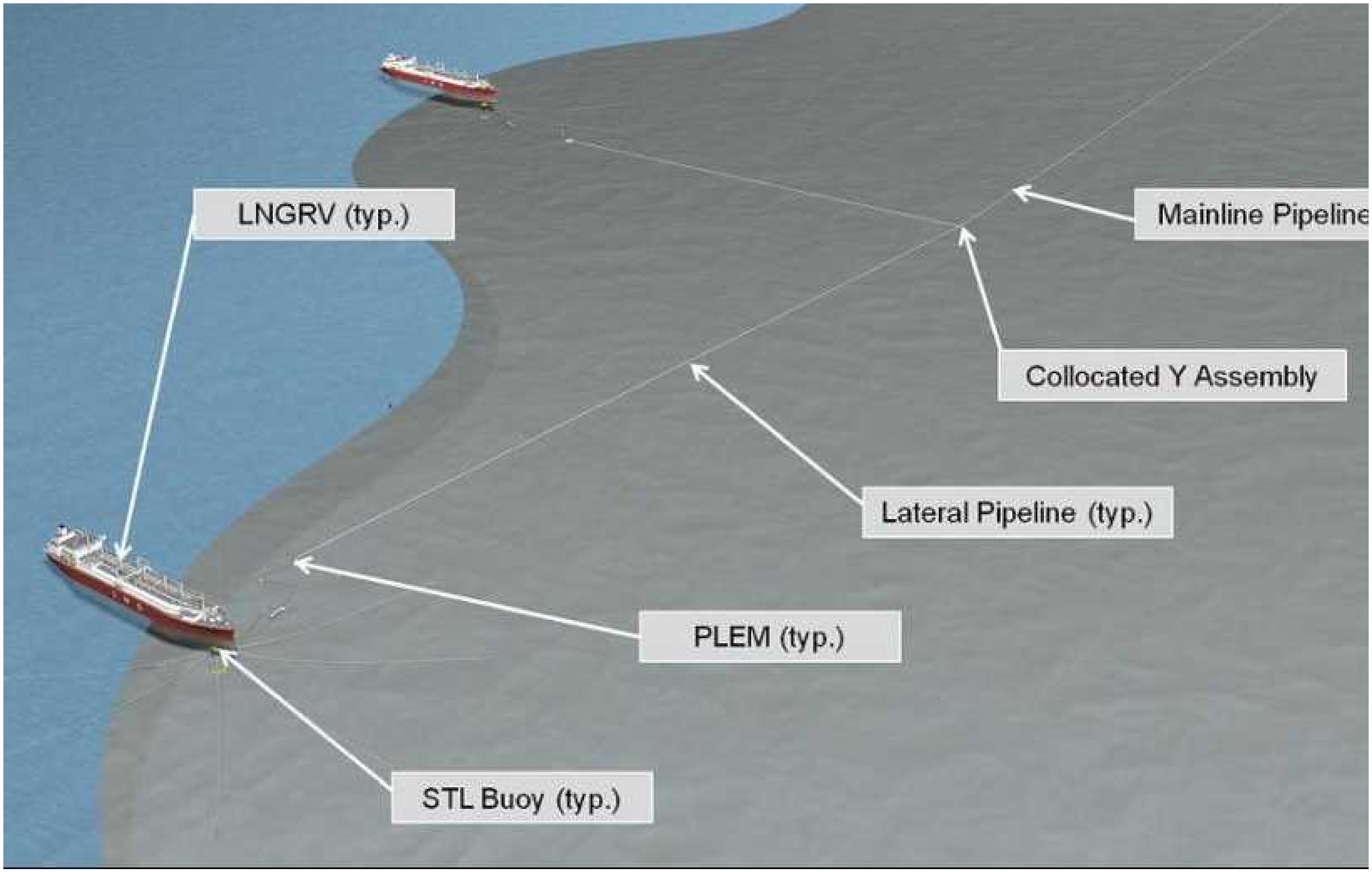
The vessels will have onboard regasification equipment to convert the LNG into pipeline quality natural gas. It is anticipated that each vessel will produce natural gas at an annual average throughput rate of 400 MMcf/d, and a peak rate of 660 MMcf/d with one or two vessels stationed at the Port. Both the newly arrived and soon-to-depart LNGRVs may be transferring gas simultaneously to ensure uninterrupted flow during peak demand.

Figure 1-3: LNG Regasification Vessel (LNGRV) Illustration

Figure 1-4 illustrates that the Port Ambrose project will be capable of mooring up to two LNGRVs simultaneously for uninterrupted off-loading and transmission of natural gas to onshore interconnection stations for delivery to customers in the New York Area.

In addition to the LNGRVs, Liberty Natural Gas, LLC will include a support vessel as part of the project. The specifics of the LNGRVs and the additional project vessel are discussed in detail as part of Section 3.

Figure 1-4: DWP Illustration



2.0 Risk Assessment Methodology

2.1 Study Basis

In order to provide useful quantitative data regarding the potential safety and security impacts of the proposed Port Ambrose Deepwater Port (DWP) project, this assessment follows the practices used in earlier Independent Risk Assessments (IRAs) conducted under the guidance of the U.S. Coast Guard (USCG) Deepwater Ports Standards Division (CG-OES-4). The objectives of the study are:

- Evaluate the potential risks utilizing appropriate site-specific data and credible scenarios to address public safety issues associated with the storage, handling, regasification, and transportation of LNG at the proposed the DWP.
- All analysis is transparent and available for review to the greatest extent possible by the public and government agencies, subject to limitations imposed by security requirements.
- Establish an independent and project-specific analysis, in lieu of extrapolation or regression of past studies or calculations.
- Follow the guidance for accidental and intentional LNG spills on water based on work conducted by Sandia National Laboratories (Sandia) and documented in the following Department of (DOE) reports[8]:
  - *Guidance on Risk Analysis and Safety Implications of a Large Liquefied Natural Gas (LNG) Spill Over Water*, 2004
  - *Breach and Safety Analysis of Spills Over Water from Large Liquefied Natural Gas Carriers*, 2008

This IRA relied on input and guidance from experts at Sandia, the USCG, federal, state and local emergency responders, law enforcement intelligence, and pilots in the development of the intentional and accidental scenarios considered.

2.2 Bounding Scenarios and Credibility

Any scenario considered in the IRA needs to be credible. This objective was achieved by developing the scenarios through the HAZard IDentification (HAZID) process which used a multidisciplinary team to propose intentional and accidental scenarios. No scenario was dismissed at this stage of the project based on likelihood. Events that result in significant consequences, but are highly unlikely, were included and represent bounding cases. To converge to this set of bounding scenarios, the following principles of scope were applied:

- The assessment is a systems level risk assessment that considers operations related to the transfer, storage, and regasification at the DWP.
- The full range of hazards was evaluated as part of an initial HAZID.
- The assessment analyzed a defined subset of the HAZID cases to bracket the credible range of potential accidental and intentional LNG release scenarios.

[8] SAND2004-6258 and SAND2008-3153

2.3 Significance Criteria and Assumptions

To determine the impact to the public, various hazard criteria must be used. The hazards of interest in the IRA are first that of thermal radiation from potential pool fires. The results calculated here are compared to criteria prescribed by USCG in the Statement of Work and include SAND2008-3153 baseline criteria. Thermal radiation hazard distances from a pool fire were estimated to two different thermal heat flux levels:

- 37.5 kW/m^2: Damage to process equipment and storage tanks,[9] for unprotected exposures based on an average 10-minute exposure duration, as well immediate fatalities
- 5 kW/m^2: Permissible level for emergency operations lasting several minutes with appropriate clothing based on an average 10-minute exposed duration[10] and onset of second degree burns based on an average 40 second exposed duration[11]

The pool fire calculations report the maximum distance to each of these thermal radiation endpoints, estimated respectively from the center of the pool fire.

In addition to the thermal radiation hazards from pool fires, the vapor dispersion from an unignited cloud resulting from spilled LNG is of interest. To determine the hazard levels associated with this potential event, the distance to the lower flammability limit (LFL) endpoint, which is 5% by volume for methane, is also reported.

These modeling endpoints were considered from spills emanating from a pool assumed to be initiated from either accidental or intentional release scenarios at the DWP location itself. While the hazard zones would also apply to the LNG regasification vessels (LNGRVs) in transit to the DWP, the figures in this report depict a pool that is centered at the buoy with the release originating at the LNGRV. The significance criteria are limited specifically to acute and fatal effects to the public (either in nearby waters or on shore). Scenarios involving long-range transport to or from the source of the LNG were not included as they are outside the jurisdiction of the USCG.

2.4 Study Approach

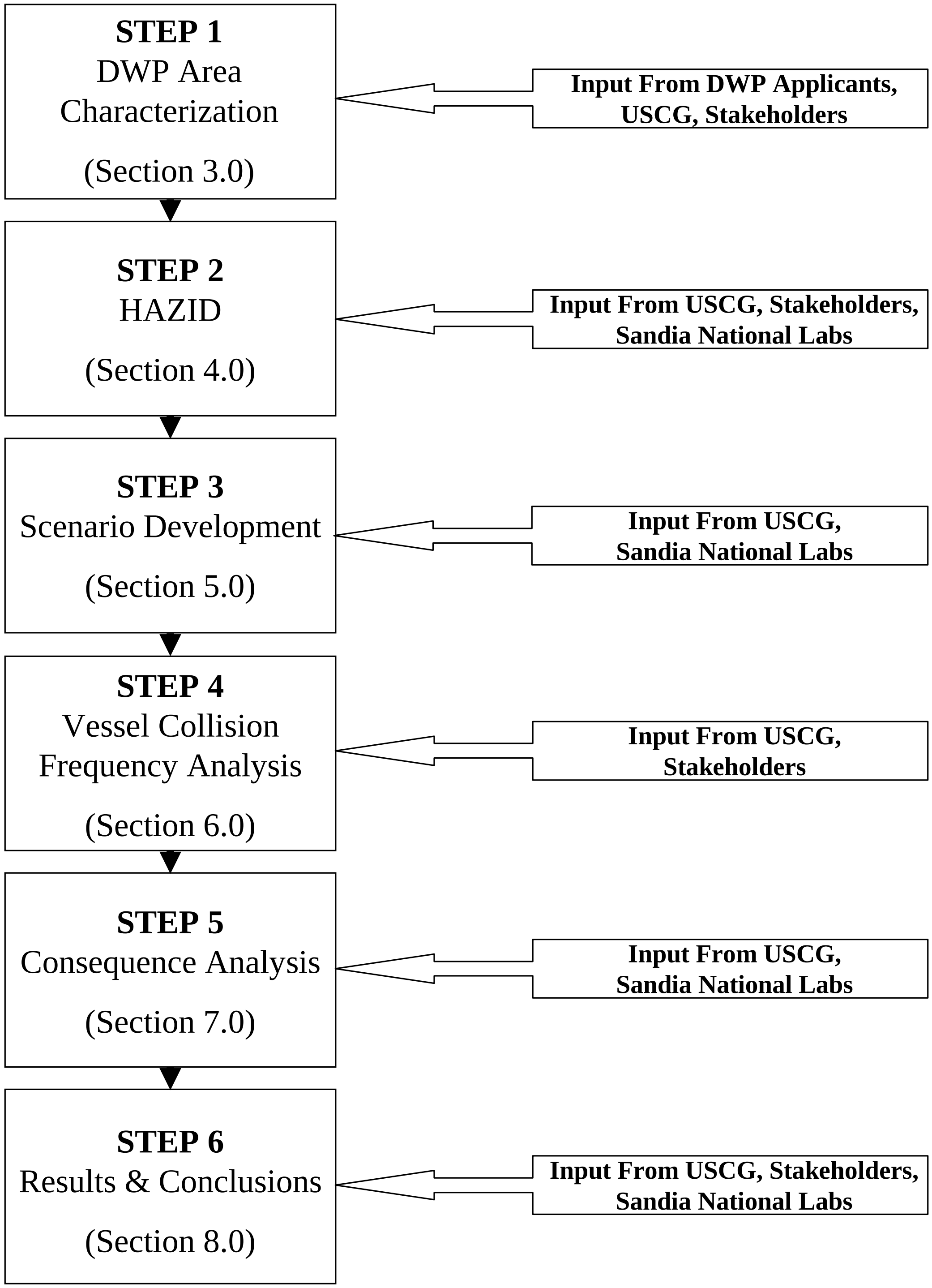
Figure 2-1 illustrates the risk assessment approach that was used to complete the analysis of this LNG DWP project. The approach was comprised of 6 steps, and included:

- **Step 1 – DWP Area Characterization**: Section 3 discusses the input data that was collected and reviewed for the risk assessment. The data included a description of the LNG DWP project, specifics on the design of the DWP location, expected size of the LNGRVs, operating conditions of the offloading, storage and regasification operation, and information on the marine traffic in the area of the proposed DWP location.

[9] Barry, Thomas, *Risk-Informed Performance-based Industrial Fire Protection* (Knoxville, TN: Tennessee Valley Publishing, 2002).
[10] Ibid.
[11] Federal Emergency Management Agency, *Handbook of Chemical Hazard Analysis Procedures*, (Washington, DC: FEMA, 1989).

- **Step 2 - HAZID**: The HAZard IDentification (HAZID) is a structured evaluation exercise that was used to identify accidental and intentional releases scenarios for this LNG DWP project. As discussed in Section 4, AcuTech facilitated a team consisting of representatives from USCG, Sandia National Laboratories, federal, state and local emergency responders, law enforcement intelligence, and pilots to identify initiating accidental and intentional events and a qualitative estimate of the potential consequences.
- **Step 3 – Scenario Development**: The development of the list of accidental and intentional scenarios evaluated in this risk assessment is discussed in Section 5. The final list of scenarios was determined by grouping similar cases from the HAZID, as well as screening out cases based on likelihood of occurrence and/or resulting consequence level, to identify the bounding accidental and intentional release scenarios for this project. Step 3 also includes a discussion of the development of the accidental and intentional release sizes. The intentional release sizes were selected based on guidance provided in SAND2008-3153 and guidance provided by Sandia specific to this project.
- **Step 4 – Vessel Frequency Collision Analysis**: Section 6 details the marine vessel traffic analysis and overall statistical likelihood of the occurrence of a vessel collision or allision with an LNGRV located at the DWP buoy locations.
- **Step 5 – Consequence Analysis**: Section 7 details the assumptions and consequence models that were used to evaluate the release scenarios defined in Step 3. This includes: LNG spill rate, pool formation and evaporation, vapor dispersion, and thermal radiation models that were used in the analysis. A solid flame model was used to calculate the thermal hazard zones and a Computational Fluid Dynamics (CFD) model was used for determining the consequences associated with vapor dispersion.
- **Step 6 – Results & Conclusions**: Section 8 combines the inputs and results of the supporting sections to evaluate the risk of this DWP project. This final step includes a discussion of the potential impacts to the public from the LNG DWP project based on the distances to the thermal radiation and flammable vapor dispersion endpoints for the accidental and intentional release scenarios modeled in the risk assessment.

Figure 2-1: DWP IRA Process



3.0 Deepwater Port Area Characterization

This section provides information to characterize and describe the proposed project area off the coast of New York and New Jersey. Information in this section is derived from the applicant's materials. Most of the information is summarized from Port Ambrose's Deepwater Port (DWP) license application (Volumes I and II General (Public)).

3.1 Proposed Port Ambrose DWP

As discussed in Section 1.3, the proposed DWP, would be located in federal waters approximately 16.5 nm (30.56 km) off Jones Beach, New York, approximately 26.9 nm (49.63 km) from the entrance to New York Harbor, in a water depth of approximately 103 feet (31.39 m). LNG would be delivered through a flexible riser/umbilical, subsea manifold and lateral pipelines to a buried 19 nm (35 km) subsea Mainline connecting to the existing Transco Lower New York Bay Lateral in New York State waters.

The components of the Project will consist of the following:

- Two (2) Submerged Turret Loading (STL) Buoy systems, comprised of the following components for each system:
  - Flexible risers;
  - Umbilicals;
  - STL Buoy pick-up assembly, which will incorporate floating messenger lines with marker buoys;
  - STL Buoy anchor points and mooring lines;
  - STL Buoy landing pads; and
  - Pipeline end manifolds (PLEMs);
- Two (2) Laterals, 0.76 nm (1.41 km) and 1.54 nm (2.85 km) in length, which will connect the PLEMs to the Mainline;
- The Mainline, which will be 19.00 nm (35 km) long and will connect to the Transco Lower New York Bay Lateral (Transco) pipeline, and;
- Subsea tie-in (SSTI) and hot-tap connections at the Transco pipeline.

3.1.1 LNG Regasification Vessels

Port Ambrose would be capable of mooring two LNG Regasification Vessels (LNGRVs). The LNGRVs are designed to carry liquefied natural gas and also to re-gasify the natural gas prior to off-loading for transport to shore. These vessels would have a capacity up to 145,000 cubic meters (m^3) of LNG, transported and stored at a temperature of -261° F (-162 ° C). Table 3-1 describes the approximate dimensions and capacities of the proposed LNGRVs that are expected to call on this DWP.

Table 3-1: Typical Dimensions and Capacities of 145,000 m^3 LNGRV

Item	Description
Hull Type	Double bottom/Double hull
Total LNG Capacity	145,000 m^3 (5,120,780 ft^3)
Number and Type of Cargo Tanks	4
Length Overall	280 m (918 ft)
Molded Breadth	44 m (142 ft)
Design Draft	11.4 m (37.4 ft)
Laden Displacement (estimated)	104,000 tonnes
Vessel Speed (calm weather)	19.5 Knots (kts)

The vessels anticipated to call on the Port will be custom-built LNGRVs.

All LNGRVs calling on the Port will have onboard vaporization and metering equipment able to convert the LNG into pipeline quality natural gas suitable for transportation in the existing natural gas pipeline system. The regasification facilities on the LNGRV will be operated using at least 99 percent natural gas, which will help ensure that Port Ambrose has minimal impact on air quality during regasification operations, and will operate as a “Closed Loop” system, which does not rely on drawn seawater as the heat source for regasification; therefore, there is no seawater intake or discharge used specifically for the regasification process. The LNGRVs will utilize a specially-designed ballast water cooling system that will entirely recirculate on board the vessel during Port operations, thus eliminating any vessel discharges while at the Port.

Liberty anticipates that the LNG will be sourced primarily from the Caribbean Islands of Trinidad and Tobago, which is historically the source of most LNG imports into the U.S.

3.1.2 LNGRV Offloading Operation

Once the LNG has been converted, it will be offloaded through the STL Buoys, into the Laterals, and then into the Mainline. Each LNGRV will moor at the Port for between five (5) to sixteen (16) days to complete the unloading process, depending on vessel size and natural gas send-out rate. The two separate buoys would allow natural gas to be delivered in a continuous flow, without interruption, by scheduling an overlap between arriving and departing LNGRVs. It is anticipated that the DWP would host 30-45 vessels per year.

The unloading buoy technology and associated equipment proposed for Port Ambrose is similar to that used offshore in projects for Massachusetts and in Florida.[12] The technology has also been successfully used in the offloading of oil and natural gas at several locations overseas, including the North Sea. Each unloading buoy would have eight mooring lines consisting of wire rope and chain. The mooring lines would connect each unloading buoy to eight anchor points most likely consisting of driven piles on the seabed. The unloading buoy is designed by Advanced Production and Loading (APL), and is also commonly known as a Submerged Turret Loading (STL) buoy. See Figure 3-1 for an illustration of the STL system.

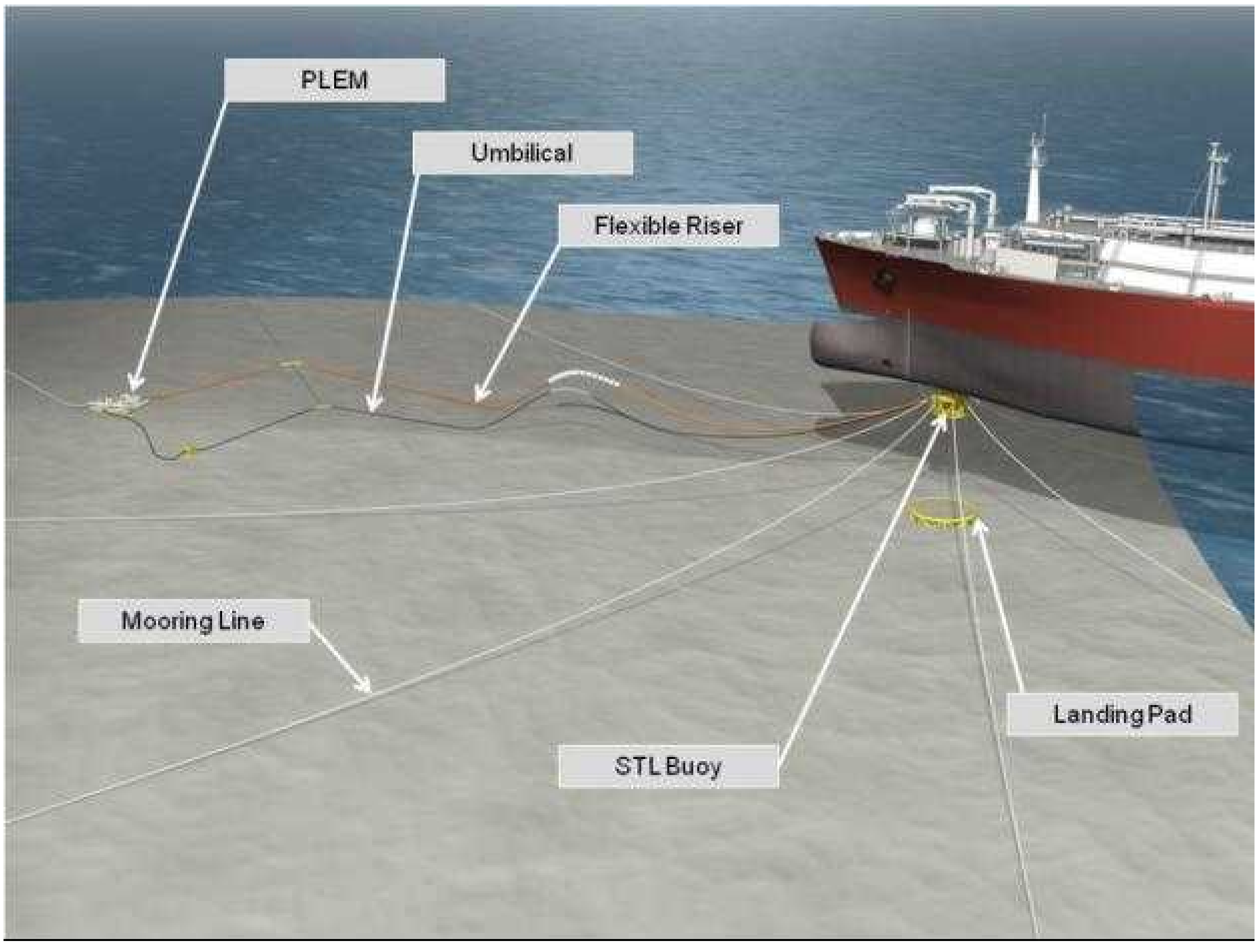
[12] Summary information on these other project is available on the MARAD website at http://www.marad.dot.gov/DWP/LNG/deepwater_ports/index.asp

The gas would be unloaded through the flexible riser into the pipeline end manifold (PLEM) for transportation to shore via the new subsea pipeline.

When the Port is not in use, the STL Buoys will be stored on the ocean floor. The exclusive use of Port Ambrose will be the off-loading and delivery of natural gas.

This proposed system for the Port Ambrose project is not capable of natural gas or LNG exports.

Figure 3-1: DWP – STL Illustration



3.1.3 Additional Project Vessels

There will be no bunkering of LNGRVs at the Port, so no vessels will be needed for that purpose. Similarly, there will be no natural gas export operations; therefore, no liquefaction vessels will operate at the port.

LNGRVs will rely upon a dedicated Support Vessel for monitoring and control purposes, as well as periodic supply and personnel transfers. This vessel will be an ocean class towing vessel of up to 130 feet (40 meters) in length, a Bollard pull (Ahead/Astern) of approximately 75 metric tons, and a draft of roughly 23 feet (7 m), and will be powered by diesel engines with up to a total of 5,000 horsepower.

It will be staffed by a crew of four to six. The Support Vessel will be equipped with firefighting capability up to DNV's FiFi1 requirements.

The Support Vessel will conduct weekly inspections of surface components of the Port. The Support Vessel will make approximately one trip per LNGRV arrival from a base of operation on the mainland.

3.2 Local Population and the Economy

If the proposed project were to impact the local economy it would most likely impact the fishing and marine tourism. The closest commercial fishing ports are Montauk and Hampton Bays-Shinnecock, New York and Long Beach-Barnegat and Point Pleasant, New Jersey. Montauk and Hampton Bays-Shinnecock are in Suffolk County New York while Long Beach-Barnegat and Point Pleasant are in Ocean County New Jersey.

In 2000 the population of Suffolk County, NY was 1,419,369 which was a 6.9% increase from the 1990 population of 1,321,864.[13] The 2012 population was 1,499,273, a 2.1% increase from 2000. The 2012 population of Ocean County, NJ was 575,961 which was a 12.7% increase from the 2000 population of 510,916. The 2000 population represented a 15.2% growth from the 1990 level of 433,203.

In 2012, total employment in Suffolk County, NY was 727,777 with 0.3% associated with the agriculture, forestry, fishing, hunting and mining category, which is lower than the New York State percentage for this category which was 0.6%. The largest employment sector for Suffolk County, NY was the education, health, and social services sector which employed 25.4% of the labor force. Unemployment in Suffolk County, NY in 2012 was 7.6% which was lower than the State of New York rate of 8.7%.[14]

In 2012, the total employment in Ocean County, NJ was 242,575 with 862 in the agriculture, forestry, fishing, hunting and mining category (0.4%). The New Jersey State percentage for this category is 0.3%. For Ocean County the largest employment sector is also education, health, and social services sector which employed 25.2% of the labor force. Unemployment in Ocean County, NJ in 2012 was 6.0% which was slightly lower than the average State of New Jersey rate of 6.3.[14]

3.2.1 Industrial Ports and Shipping

The Port Authority of New York and New Jersey has a number of marine terminal facilities. It has three cruise terminals (Manhattan, Brooklyn and Cape Liberty) and addresses a wide range of cargo including containers, autos, liquid and dry bulk, break bulk and specialized project cargo.

A 2011 study by A. Strauss-Wieder, Inc. on the economic impact of the New York New Jersey Port Maritime Industry found that in 2010, the industry supported 170,770 jobs, 11.6 billion in personal income and 37.1 billion in business income.[15]

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[13] 2007-2011 American Community Survey 5-Year Estimates.
[14] U.S. Bureau of Labor Statistics, 2012.
[15] http://www.panynj.gov/about/pdf/port-economic-impact-2011.pdf

3.2.2 Existing Activities near the Proposed Project Area

The project area is part of a busy shipping zone (Figure 3-2). While the distance from shore discourages casual boating and fishing, this leaves charter boats, cruises and commercial fishermen to utilize.

Marine traffic includes all vessels, commercial, and/or recreational, that use:

- Inbound/outbound traffic lanes of the Port of New York and New Jersey;
- Channels and navigable waterways within the New York Vessel Traffic Service (VTS) area;
- Open waters offshore the New York VTS area, where jurisdiction of the U.S. Coast Guard (USCG); and
- Hudson River, Port of Albany, and other smaller ports along the Hudson River.

Within the Port of New York and New Jersey, marine traffic is composed of a variety of vessels engaged in commercial, recreational, federal, and state functions. For this Project, the affected environment for marine transportation includes those offshore components that could be directly or indirectly impacted during construction and/or operations and by movement of LNGRVs and the Support Vessel. These areas include the New York Harbor channel system and the Traffic Separation Scheme (TSS) shipping lanes, as well as inshore marine terminals and other shoreline facilities. The following sections describe the existing marine traffic environment.

3.2.3 Commercial Fishing

The proposed site is located at least 10 nm from identified commercial fishing grounds within the area, including Cholera Bank, Middle Ground, Angler Bank, Mussel Ridge, Atlantic Beach Reef and Hampstead Town Reef. Vessels departing from Long Beach, Barnegat and Port Pleasant ports would most likely to cross through the DWP Project area due to their location in relation to the Project area. In 2011, 354 vessels in New York and 506 vessels in New Jersey had permits on record with National Oceanographic & Atmospheric Administration (NOAA) Fisheries. A total of 4,731 were on record with NOAA for the northeast in 2011.

In 2007 New Jersey and New York ranked 9th and 15th respectively out of the 48 continental states in the total volume of commercial fish landings.[16] This represented 4% and 1% of the total volume of landings in the states. In terms of value, New Jersey ranked 6th with 6% and New York 14th with 2% of all landing value.[17] In 2007 the New Jersey landings were almost 154 million pounds (70 thousand metric tons) valued at $127 million. That same year the New York landings were almost 36 million pounds (17 thousand metric tons) valued at $49 million.

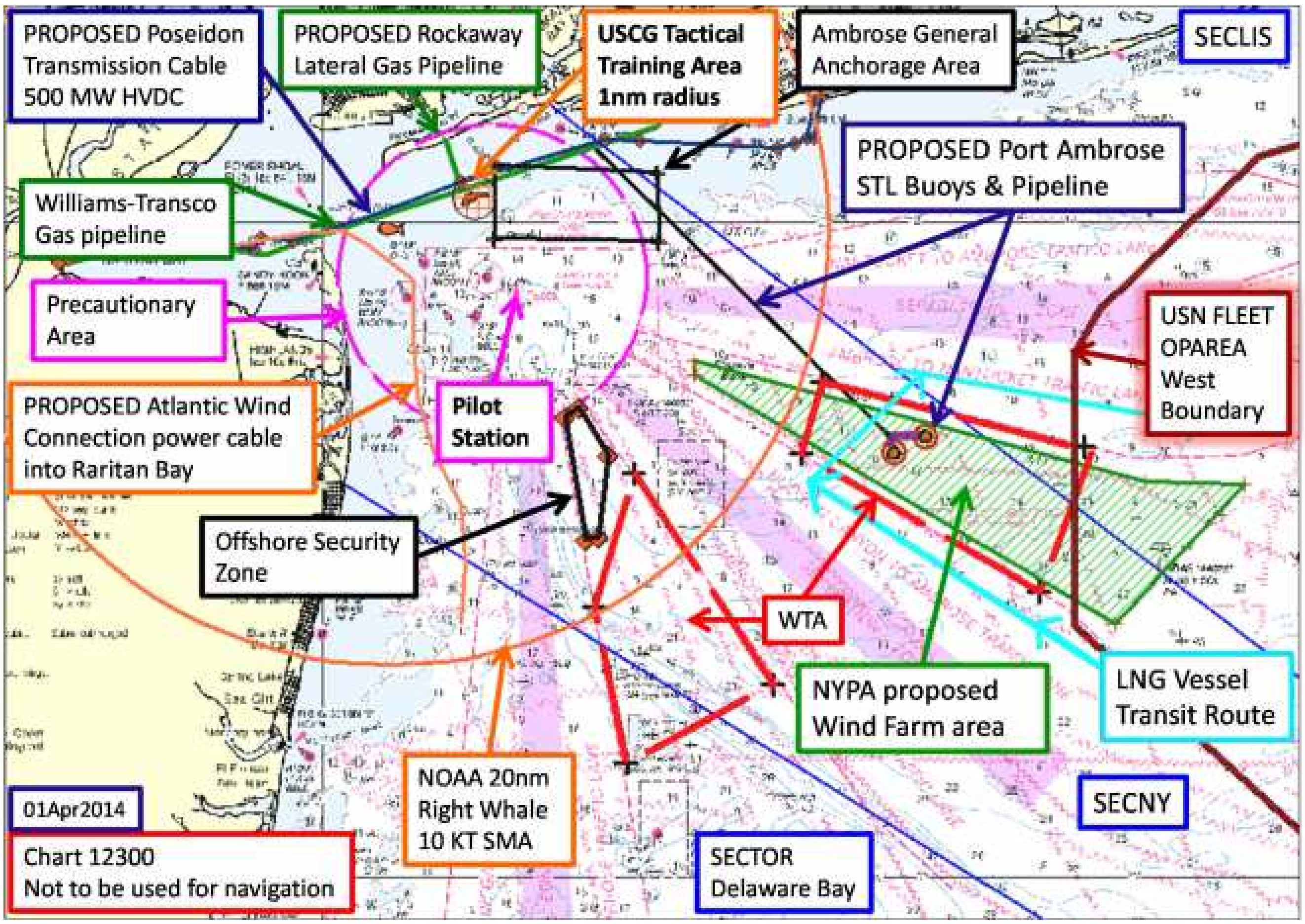
The 2011 commercial landings at Hampton Bay-Shinnecock and Montauk, the two closest ports in New York to the proposed DWP site, totaled approximately 19.3 million pounds (8.8 thousand metric tons) for a total value of $26.2 million. The two closest ports in New Jersey, Point Pleasant and Long

[16] A landing are those fish and shellfish that are landed and sold in the 50 states.
[17] National Marine Fisheries Service (NMFS), 2007.

Beach-Barnegat, had combined total landings of 24.2 million pounds (11.0 thousand metric tons) for a total value of approximately $60.6 million.[18]

The charter season typically runs from mid-March to mid-November and both inshore and offshore areas (artificial reefs and wrecks) are fished. National Maritime Fisheries Service (NMFS) tracks commercial trip data by individual statistical areas. The proposed Port is located in Regional Statistic Area 612, Blocks 44 and 45. A total of 860 commercial fishing trips were made to Blocks 44 and 45 in 2008, but the vast majority of these trips made were made outside of the proposed DWP location.

Figure 3-2: Port Ambrose Proposed Project Location



3.2.4 Recreational Boating and Water-Based Tourism

Recreational boats include runabouts, yachts, small charters, and sail boats. These vessels can be launched or are docked at shore-based facilities along the New York coastline. Vessel draft and length are restricted based on marina and channel depth limitations.

[18] NOAA Fisheries - Total Commercial Fishery Landings at Major U.S. Ports Summarized By Year and Ranked By Dollar Value (2011)

Boats under 26 ft (8 m) in length are particularly likely to be transported by trailer and will frequent launching facilities whereas larger vessels will use marinas. Due to draft limitations associated with the controlling depths of surrounding channels, inshore marinas primarily accommodate shallow draft recreational vessels with drafts ranging between 3 and 6 ft (1 and 2 m).

It is anticipated that vessels located in Kings, Queens and Richmond Counties, New York and Middlesex, Monmouth, and Ocean Counties, New Jersey could travel to the proposed Project area. Table 3-2 details the number of boats registered in Kings, Queens Counties, New York according to the 2010 New York State Recreational Boating Report and the 2008 Recreation Boating in New Jersey: An Economic Analysis Report. Offshore access to the proposed site is limited by draft and the limited number of access channels through East Rockaway, Rockaway, and Jones Inlets along the barrier island. Using New York City Department of Parks and Recreation (2010) data, nine boat launching facilities were identified.

Table 3-2: Registered Boats in Kings, Queens and Richmond Counties, New York and Middlesex, Monmouth and Ocean Counties, New Jersey

COUNTY	NUMBER OF REGISTERED BOATS
Kings County, New York[19]	4,378
Queens County, New York[18]	6,991
Richmond County, New York[18]	3,994
Middlesex County, New Jersey[20]	10,171
Monmouth County, New Jersey[19]	17,710
Ocean County, New Jersey[19]	28,231

It should be further noted that recreational vessel traffic inshore southern Long Island and offshore Long Island is seasonally variable. Vessels are more frequent in the warmer months between May and October and are concentrated within the various inlets, New York state waters, or around submerged structures and artificial reefs offshore. These vessels are relatively small, averaging between 21 and 35ft (7 and 11 m).

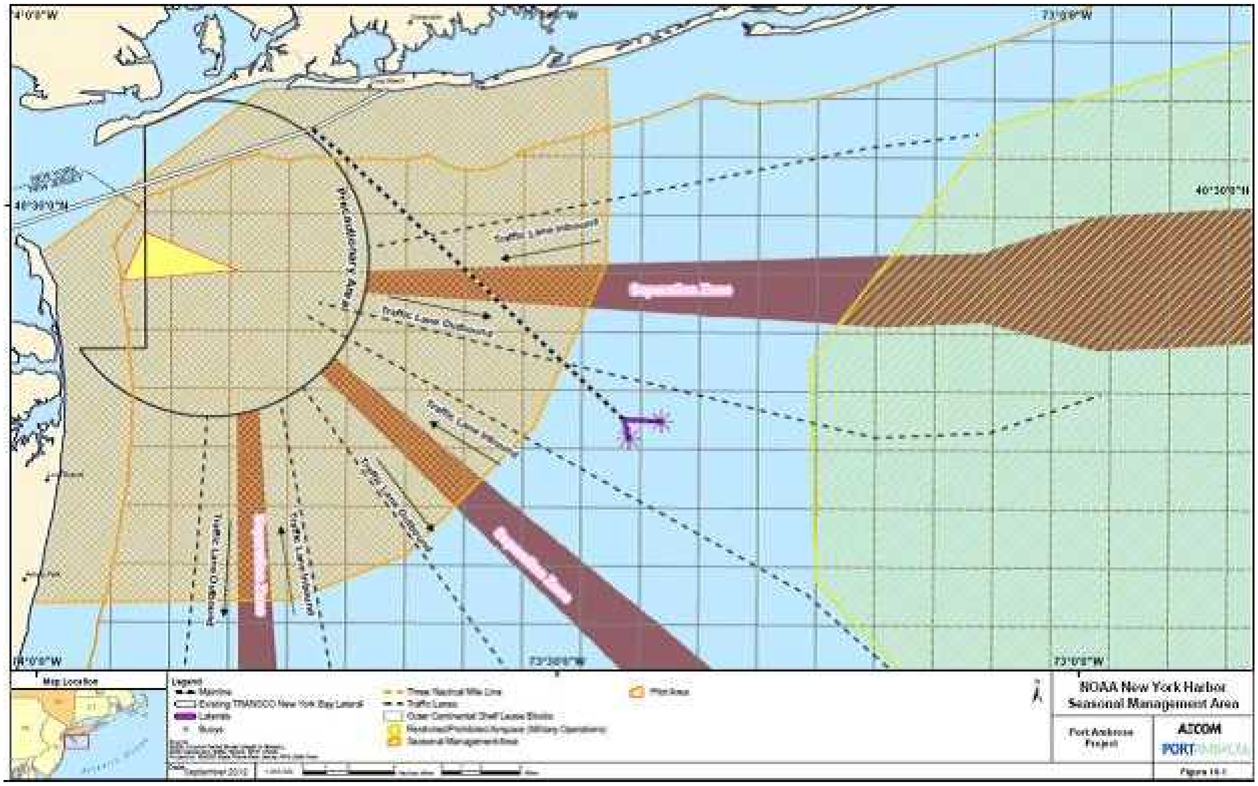
3.3 Marine Traffic Management

TSSs have been established in the approaches to New York Harbor from the sea to increase the safety of navigation (Figure 3-3). These include the eastern approach of Ambrose to Nantucket/Nantucket to Ambrose TSS, the centrally located Hudson Canyon to Ambrose/Ambrose to Hudson Canyon TSS, and the southern approach of Barnegat to Ambrose/Ambrose to Barnegat Port Ambrose Project TSS. TSSs or traffic/shipping lanes are designed to provide safer passage of vessels in converging areas of high traffic density.

Of the six aforementioned traffic lanes, the Hudson Canyon to Ambrose Inbound Traffic Lane is located west and the Ambrose to Nantucket Outbound Traffic Lane is located east north-east of the proposed mooring locations. The remaining shipping lanes are located farther outside of the proposed STL Buoy locations and are not considered to be of consequence.

[19] New York State 2010 Recreational Boating Report
[20] 2008 Recreation Boating in New Jersey: An Economic Analysis

Figure 3-3: Port Ambrose Proposed Project Location



3.3.1 Safety and Security Zones

As stated in 33 CFR Part 165, Subpart C (Navigation and Navigable Waters), "a Safety Zone is a water area, shore area, or water and shore area to which, for safety or environmental purposes, access is limited to authorized persons, vehicles, or vessels. The Deepwater Port Act directs that a safety zone be established around and including any deepwater port for the purpose of navigational safety. 33 CFR Part 150, Subpart G, authorizes the Coast Guard to establish a deepwater port safety zone. When an LNGRV is moored at Port Ambrose, it would be protected by a safety zone, extending 500 meters in all directions from the outermost portion of the hull of the LNGRV (i.e., stern) as it weathervanes on the buoy.

There are no existing safety zones charted on or adjacent to the proposed STL Buoy locations. However, there are security zones (33 CFR 165.169) surrounding bridge piers and abutments and JFK Airport within Jamaica Bay, the offshore Approaches to New York, Atlantic Ocean security zone that are within 25 nm of the two STL buoys. There are also security zones surrounding liquefied hazardous gas (LHG) vessels, cruise ships, and other designated vessels that would transit within 25 nm of the Port Ambrose project

Established under the authority of 50 U.S.C. 191 and 33 CFR 6.04-6, Security Zones are "all areas of land, water, or land and water, which are so designated by the Captain of the Port (COTP) for such time as is deemed necessary to prevent damage or injury to any vessel or waterfront facility, to safeguard ports, harbors, territories, or waters of the United States or to secure the observance of the rights and obligations of the United States." Coast Guard authority to establish security zones is applicable only to waters subject to the jurisdiction of the United States, including the territorial sea to a seaward limit of not more than 12 nautical miles. As Port Ambrose is proposed to be located outside of this limit, no security zones will be established. There are no existing security zones within 25 nm (40 km) of the Project.

3.3.2 Anchorages and Special Anchorage Areas

A Special Anchorage Area, set forth in 33 CFR 110.1, is an area where vessels of less than 20 meters in length, and barges, canal boats, scows, or other nondescript craft, are not required to sound signals required by rule 35 of the Inland Navigation Rules (33 U.S.C. 2035). Vessels of less than 20 meters are not required to exhibit anchor lights or shapes required by rule 30 of the Inland Navigation Rules (33 U.S.C. 2930). There are no Special Anchorage Areas located near the Project site.

The extent of a No Anchoring Area (NAA) proposed for the Port Ambrose Project is to avoid entanglement by any vessel's anchors and the mooring lines and anchors for the STL buoys and the pipeline. The NAA for the buoy site is proposed by the Applicant to be an area defined by the outer bounds of each STL buoy anchor system, with a radius of 1000 meters.

3.3.3 Area to Be Avoided (ATBA)

The ATBA proposed by the Applicant is proposed to have the same shape as for the NAA for the buoy site, with a radius of approximately 1000 meters from each buoy. This ATBA would help to ensure that other vessels do not interfere with the DWP operations, including maneuvering of LNG carriers and support vessels. The actual size of the ATBA would be determined, in consultation with the USCG Navigation and Standards Branch with input from the Captain of the Port. Upon its approval from IMO, the ATBA would appear on subsequent nautical charts after chart corrections are published in the Local Notice to Mariners. The ATBA is recommendatory and is meant to discourage vessel traffic in the area.

3.4 Marine Traffic Data

The following issues related to marine traffic in the project area were considered and examined in this risk assessment as they constitute a possible impact to the public in or near the project area:

- Potential increased vessel traffic (traffic associated with the proposed DWP in the area surrounding the Port of New York and New Jersey)
- Potential impact of safety zones and areas to be avoided by vessel traffic around the Port Ambrose DWP
- Potential interference with use and access to current fishing areas and other mariners and vessels transiting areas around the DWP
- Potential for collision between ships entering or departing Port of New York and New Jersey with the LNGRVs calling at the proposed DWP location

3.4.1 Commercial Shipping Traffic

U.S. Coast Guard (USCG) R&D Center, provided vessel traffic data around the area of interest around this proposed DWP (the AIS study area is highlighted on Figure 3-2). The Automatic Identification System (AIS) provided a one-year data set from October of 2011 to September of 2012 and includes these types of vessels:

- Passenger
- Cargo
- Tanker
- Other Vessels

Table 3-3: Annual Shipping Movements (October 2011 – July 2012 AIS Data covering an area bounded by Latitude 40° 10' to 40° 30' North and Longitude 73° 10' to 73° 40')

VESSEL TYPE	NUMBER OF VESSEL MOVEMENTS
Passenger	152
Cargo	2,131
Tanker	1,134
Other Vessels (including unknown)	258
TOTAL	**3,675**

In addition to vessel types and counts, the AIS data also included:

- Displacement
- Speed
- Kinetic Energy

This AIS data set was used to determine the bounding vessel collision breach size for the LNGRV and was used as input to the vessel collision frequency analysis. In these analyses, the number of vessels has been limited to those with sufficient size (displacement) and speed to potentially breach the inner hull of a LNGRV in a vessel collision, resulting in a release of LNG.

Table 3-4 details the range of displacement, average speed, and absorbed energy for the subset of vessels identified from the AIS data with the potential to breach the inner hull of a LNGRV.

Table 3-4: Vessel Type Impact Energy

Vessel Type	Displacement (tonnes)	Average Cruising Speed (knots)	Kinetic Energy (N-m)
Passenger	84 – 127,738	18.3	$6.49 \times 10^{5} – 1.11 \times 10^{10}$
Cargo	2,379 – 169,153	18.5	$2.97 \times 10^{7} – 1.24 \times 10^{10}$
Tanker	1,744 – 183,141	13.4	$1.51 \times 10^{5} – 4.93 \times 10^{9}$
Other vessel	24 – 188,166	10.3	$4.85 \times 10^{5} – 5.29 \times 10^{9}$

It is noted that the AIS dataset that does not account for seasonal or any other variations in traffic.

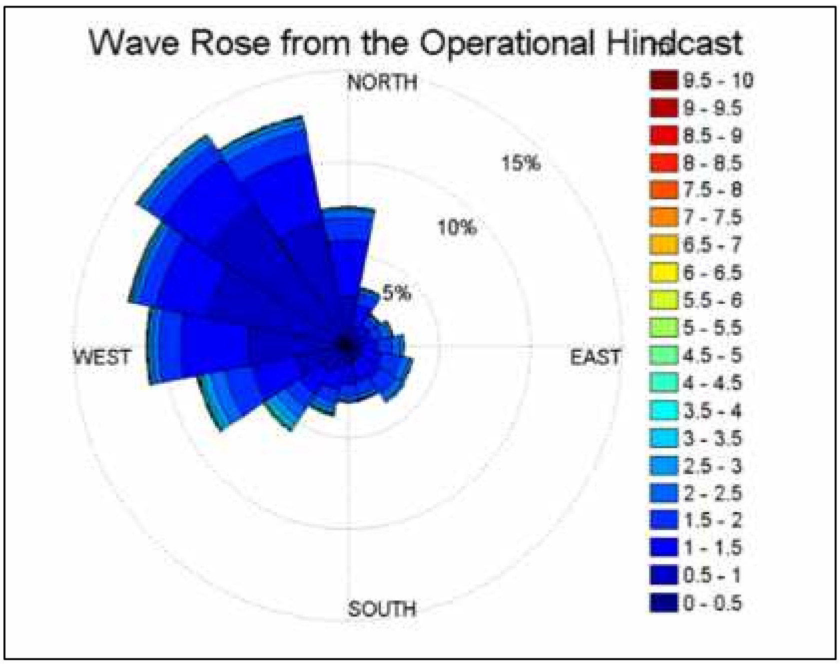
This vessel data has been applied in the breach size calculations in this Section 5, as well as the vessel collision frequency analysis in Section 6.

3.5 Weather at DWP Location

Winds, waves and tides are important when considering the risk associated at the DWP site. The Port Ambrose application contains metocean data for the project location. The follow is a summary of this information.

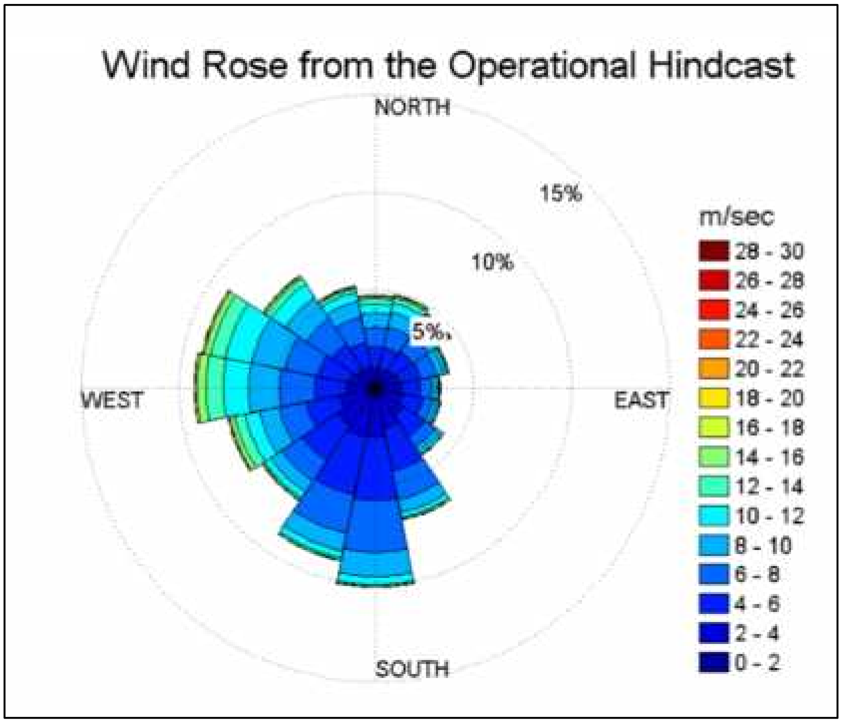
The wave height and period data was developed from the continuous Oceanweather hindcasts
A wave rose of the data is shown in Figure 3-4, and is in the direction toward which the waves are traveling. The predominate wave direction is to the northwest.

Figure 3-4: Wave Rose from Operational Hindcast for Project Location



The wind speed and direction was also developed from the continuous Oceanweather hindcasts. The data shows the percentage of the time that the specified wind speed and direction occurred during the operational hindcast. A wind rose of the data is shown in Figure 3-5. The winds are predominantly from the south.

Figure 3-5: Wind Rose from Operational Hindcast for Project Location



The current speed and direction data was developed from the Rutgers CODAR measurements. A current rose of the data is shown in Figures 3-6. Currents in all directions are equally likely.

Figure 3-6: Current Rose from CODAR for Project Location

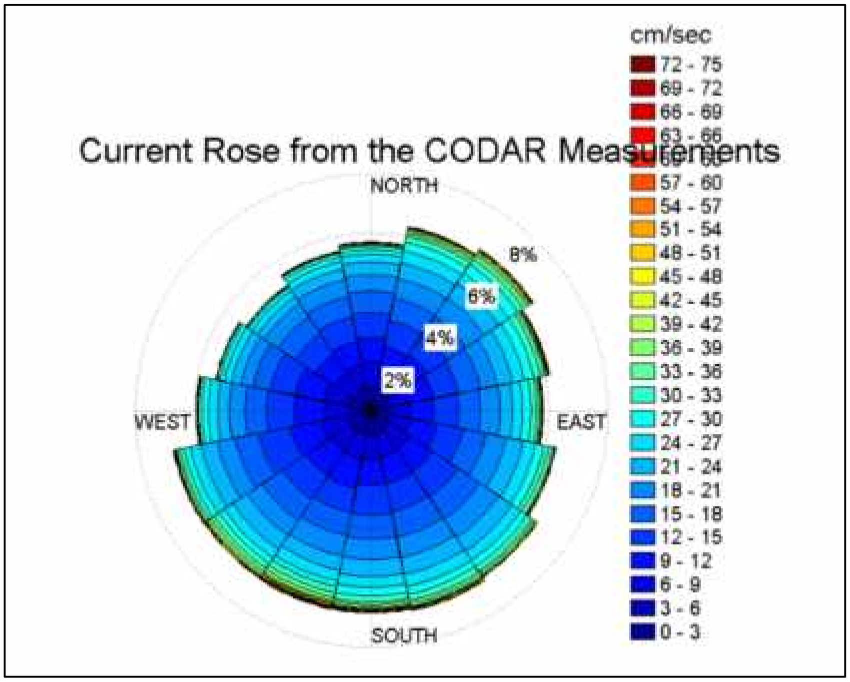


Table 3-5 details the Metocean data for the proposed Safe Harbor Energy DWP site.

Table 3-5: Metocean Data for the Proposed Port Ambrose Project Location

Parameter	Value
100 Year Wind Speed	33.27 m/s
100 Year Significant Wave Height	8.54 m
Maximum Measured Surface Current	87.5 cm/s

The LNGRVs will monitor current and forecasted weather conditions through regular monitoring of the vessel's equipment (such as radar, barometer, anemometer, and visual observation from the bridge) as well as monitoring National Weather Service internet and VHF voice broadcasts of current and forecasted marine conditions, Dial-A-Buoy service from Station 44065-Entrance to NY Harbor, real-time weather radar satellite imagery via internet, and mass media weather broadcasts available by satellite on the vessel's TV system.

The Port Manager and LNGRV Master at the first sign of significant weather will determine the Master's needs and plans for storm evasion, such that any order to evacuate will be done in a manner timely enough to allow safe weather evasion. Evacuation due to forecasted weather in excess of the limits below will be ordered by the Port Manager in consultation with the LNGRV Master, and in accordance with the COTP New York Hurricane and Severe Weather Plan. Proper notifications and consultations with USCG will be made.

In addition the STL system components are designed for:

- LNGRV to stay connected in the 10-year storm condition
- Idle system will survive the 100-year storm condition

Severe weather was considered in both in the Port Ambrose DWP application and during the HAZID process, described in Section 4.0. Due to the relatively predictable weather around the port, combined with the robust ship and equipment design, procedures to predict adverse weather conditions, and the ability to disconnect from the buoy should severe weather develop suddenly during transfer operations,[21] significant damage to an LNGRV or the DWP due to severe weather is considered unlikely.

3.6 Proposed Wind Energy Area

The proposed Port Ambrose falls within the proposed area of interest for the wind energy project(s) proposed for offshore New York as described in the Bureau of Ocean Energy Management's Call for Information of May 28, 2014 (79 FR 30645). The risk assessment will take this proposal into account; however, because of the lack of wind energy specific project details, this report is necessarily constrained in its ability to provide an analysis of the navigational safety risks that operation of the deepwater port may have on a future wind farm siting and operation. While it would be inappropriate for this report to purport to establish specific setbacks between the deepwater port, vessels operating in

[21] Port Ambrose Application, Vol. III, Sec. 9 (Draft Operations Manual) (Confidential).

the area, and the wind farm, this report does provide information on LNG spill consequences which will help inform any future offshore wind energy project proponent on future siting of wind turbines.

The operation of the port will incorporate a number of risk mitigation measures which may serve to lessen the risk of adverse consequences between the deepwater port's operation and the construction and operation of a wind farm. These measures include, but are not limited to: the stationing of tug assist at the port prior to an LNGRV arriving which will be available to render immediate assistance in the event of a marine casualty (e.g., loss of propulsion or steering), measures that restrict port operations if certain wind and sea state conditions are exceeded, and other emergency procedures contained in the port Operations Manual. To the extent practicable, in the absence of a detailed wind farm application, the Phase II portion of the IRA will examine navigational safety concerns and consider applicable measures that may serve to mitigate potential risks of both facilities operating in the same geographic area.[22]

[22] This IRA does not establish enforceable requirements on any potential future wind farm operator. The BOEM may consider this information as it determines what, if any, operational restrictions may need to be imposed on a proposed wind farm. Pursuant to the Memorandum of Agreement between (then) BOEMRE and the USCG (dtd 27Jul2011), the USCG will assist BOEM in assessing the navigational risks that may be posed by renewable energy development projects, For additional information, see Navigation and Vessel Information Circular, 02-2007, "Guidance on the Coast Guard's Roles & Responsibilities for Offshore Renewable Energy Installations (OREI)."

4.0 Hazard Identification (HAZID) Study

The HAZID was a comprehensive review of the applicant's proposed DWP operation, including operation of the Shuttle & Regasification Vessels (LNGRV) and offloading at the buoys. The purpose of the HAZID is to develop and review credible accidental and intentional events (scenarios) that could potentially impact the public, and that will be analyzed throughout the Independent Risk Assessment (IRA) process.

The HAZID workshop was conducted on January 16-17, 2014, at the Maher Terminal Training Room in Elizabeth, New Jersey. AcuTech facilitated the meeting and the HAZID team included representatives from U.S. Coast Guard (USCG) Sector NY, USCG CG-OES-4, Sandia National Laboratories, Port Authority of New York and New Jersey and USCG, federal, state and local emergency responders, law enforcement intelligence, and pilots listed in Table 4-1.

The first day of the HAZID workshop included the applicant's overview presentation of the proposed Port Ambrose project to the HAZID team. This presentation from Liberty Natural Gas, LLC included an overall project familiarization including the regasification and transfer process, ship traffic data, meteorological conditions, and information on the LNGRVs. Following the presentation, the applicant was excused and the HAZID team utilized the remaining time to evaluate potential events that could impact the DWP and its operations and in-turn cause negative impact to the public.

4.1 HAZID Process

The focus of this IRA is potential impact to the public. Therefore during the HAZID process worst but credible accidental and intentional scenarios involving the Port Ambrose Deepwater Port (DWP) were considered. The most prevalent material located at the DWP which could produce consequences of a negative nature is the large amounts of LNG in the carriers. Therefore, the emphasis of the HAZID was on the identification of events that could lead to large releases of LNG and potentially impact populations including those onshore, and on private or commercial vessels (those not associated with the project) in the vicinity.

Because the scenarios were being defined without prior knowledge of the resulting consequence, no scenario proposed by the team was dismissed due to criteria that the final impact would be small. Also no scenario was dismissed because it was deemed to be highly unlikely to occur. If based on the experience and knowledge of the participants a scenario was deemed to be credible it was considered.

As a minimum baseline, the following scenarios were discussed and evaluated to determine their suitability for further analysis:

- Marine collision and/or allision that results in penetration of LNG cargo containment
- Mechanical or structural system failure resulting a major accidental LNG spill
- Fire resulting in cascading events leading to compromise on LNG containment
- Severe weather to include lightning, wind, waves or currents
- Dropped objects
- Direct attack using vessel or performed by a single or multiple intruders
- Standoff attack
- Sabotage

- Hazards associated with proximity to USCG operations that occur in the area
- Coexistence and hazards associated with proximity to the proposed area of interest for the wind energy project(s) proposed for offshore New York as described in the Bureau of Ocean Energy Management's Call for Information of May 28, 2014 (79 FR 30645).

The IRA focused solely on the specific maximum potential impacts to the public associated with offshore storage and regasification of LNG at the proposed DWP; therefore, processes beyond the Pipeline End Manifold (PLEM) and pipeline failures were not considered as part of the HAZID.

4.2 HAZID Scope

The Port Ambrose HAZID Workshop participants analyzed the following operational segments:

1. LNGRV in Transit to DWP
2. DWP
    - 2.1. Mooring System
        - 2.1.1. One LNGRV at DWP
        - 2.1.2. Two LNGRVs at DWP
    - 2.2. Transfer System
        - 2.2.1. Regasification Skids on LNGRV
        - 2.2.2. Submerged Turret Loading (STL) Buoy System
    - 2.3. PLEM
    - 2.4. PLEM to pipeline
    - 2.5. USCG operations that occur in the area
    - 2.6. Coexistence with wind energy project(s) proposed for offshore New York as described in the Bureau of Ocean Energy Management's Call for Information of May 28, 2014 (79 FR 30645).

The following segments were excluded from consideration:

1. LNGRV in transit to and from Port (outside of Traffic Separation Scheme (TSS))
2. Pipeline to offshore pipeline connection

4.3 Port Ambrose HAZID Workshop Attendees

Table 4-1: HAZID Participant List

Name	Comments
U.S. Coast Guard Headquarters, Deepwater Ports Standards Division, CG-OES-4	
U.S. Coast Guard Headquarters, Navigation Standards Division	
U.S. Coast Guard, Sector New York	
U S Coast Guard District One	
US Maritime Administration	
U S Bureau of Ocean Energy Management	
AcuTech Group, Inc.	
Sandia National Lab.	
New York Office of Homeland Security	
New York State – Dept. of State	
New York State – Dept. of Environmental Conservation	
New York Power Authority	
New Jersey – Dept. of State	
New York City – Office of Emergency Management	
New York City Fire Department	
New York City Police Department	
New York New Jersey Port Authority	
Sandy Hook Pilots	
Maritime Association of the Port of New York New Jersey Tug & Barge Subcommittee	
Liberty Natural Gas LLC	Applicant present 09:00-12:30 on day one and available to respond to technical queries for the remainder of the HAZID.

5.0 Scenario Development

Following the HAZard IDentification (HAZID), the identified scenarios were further reviewed and a subset was selected for further development in the risk assessment. A copy of the HAZID results was submitted to the U.S. Coast Guard (USCG), but is not appended here as it contains information pertaining to intentional acts, which has a homeland security concern. While the full HAZID is not presented, the key findings have been carried through this section.

A subset, as opposed to a full range of accidental and intentional scenarios, was analyzed in this risk assessment since the purpose of this analysis is to identify the results of the bounding credible worst-case release scenarios. The process that the USCG requires for the evaluation of a LNG Deepwater Port (DWP) project application is comprised of two phases: Phase I of the IRA evaluates the worst credible accidental and intentional scenarios; Phase II of the Independent Risk Assessment (IRA) will evaluate the full range of all possible releases to develop the safety and security strategy for the security and operations manuals. Phase II also discusses various mitigation measures that may be employed to reduce the risk of the identified hazards. This section discusses all of the scenarios identified during the HAZID process and presents information and analysis used to screen-out cases which were deemed not to be the bounding cases.

In addition to discussing the method that was used to select the final accidental and intentional release scenarios, this section also details the resulting consequences that were modeled (i.e., breach sizes). For the release scenarios included in the risk assessment, this is defined as an expected breach size in the inner hull of a LNG regasification vessel (LNGRV), a release from process equipment, or any other locations or scenario where LNG could be potentially released.

Section 7 details the analysis of the consequences and the resulting thermal radiation hazard distances and flammable vapor cloud dispersion results from the intentional and accidental scenarios.

5.1 Accidental Scenario Development

The HAZID identified twelve potential accidental release scenarios that have the potential to result in a release of LNG. These accidental scenarios included:

- Scenario 1 – Vessel Collision / Allision
- Scenario 2 - Shipboard Mechanical System Failure
- Scenario 3 - Fire
- Scenario 4 - LNG Release at Process Equipment
- Scenario 5 - Severe Weather
- Scenario 6 - Structural Failure of LNG LNGRV (including the tanks)
- Scenario 7 - Grounding
- Scenario 8 – Mooring System Failure
- Scenario 9 - Aviation
- Scenario 10 – Natural Phenomena
- Scenario 11 – Dropped Objects
- Scenario 12 – Buoy Entanglement

The accidental scenarios were discussed and reviewed with the HAZID participants and evaluated based on scenario significance. Based on that review, Scenario 1 – Vessel Collision / Allision was identified as the scenario with the greatest potential of significant LNG release.

5.1.1 Marine Release

During the past 45 years, there have been approximately 100,000 LNG carrier voyages,[23] covering more than 235 million miles.[24] There is no report of any accident involving a LNG carrier underway that has resulted in an unintentional release of LNG cargo. This covers export locations (e.g., Alaska, Algeria, Trinidad, Indonesia) and various import locations (e.g., Boston, Lake Charles, Savannah, and several locations in Japan and Korea).

Many of these locations are in ports and environments more busy and complex than that of the proposed Port Ambrose DWP and present greater potential for collisions, allisions, and groundings than this location. It would be inaccurate to state that there have been no marine mishaps involving LNG carriers. Over the life of the industry, sixteen cargo transfer incidents worldwide have resulted in limited LNG spills with some damage, but no cargo fires have occurred.[25] In addition to these cargo transfer incidents, there have been collisions, groundings, loss of vessel propulsion, cargo tank leaks, vent riser fires, insulation fires, and other miscellaneous incidents involving LNG carriers, but none of these incidents have resulted in a release of LNG to the environment.

The maritime scenarios identified in the HAZID include collision/allision, mechanical failure, groundings, and other accidental and intentional acts. Even though historically there are no reported marine accidents that have resulted in a breach of containment, the vessel speeds and sizes that traverse the open waters and the vessel safety fairway near the Port Ambrose DWP location have the potential to significantly damage an LNGRV, if a collision were to occur.

The expected breach size on the inner hull of an LNGRV from a vessel collision scenario is presented in Section 5.3. Marine collision is also presented in Section 6 as part of the collision analysis to determine the frequency of a vessel collision with the LNGRV that could result in a breach of containment and loss of LNG to the environment.

The buoys for the Port Ambrose DWP project are located approximately 16.1 nautical miles away from any landmass or shallow water, reducing the chance of a grounding event. Therefore, the grounding of an LNGRV in transit to and from the buoy has not been evaluated as a bounding scenario and screened-out for further consideration.

5.1.2 Process Release

In addition to the release of LNG associated with a possible collision/allision, several other types of scenarios are possible with the LNG carriers associated with the Port Ambrose project. Since an

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[23] A "voyage" is defined as both the loaded and unloaded LNG carrier movement between the loading port and discharge port.
[24] Data compiled from SIGGTO 1976-2000 and International Group of Liquefied Natural Gas Importers, *The LNG Industry* (Clichy, France: International Group of Liquefied Natural Gas Importers, 2002-2006).
[25]USCG DWP Standards Division maintains LNG accident/incident data. This data will be included as an Appendix to the DEIS/FEIS.

LNGRV has significant top-side processing equipment for the regasification of LNG and the distribution of natural gas to the subsea pipeline, there is a potential for process-related releases. These scenarios involve equipment failures, human errors, or external events (weather-related events are addressed separately) that can result in a release of LNG or natural gas leading to fires, explosions, or other serious shipboard events. Similar consequences could also be initiated intentionally via onboard sabotage.

The Applicant proposes that all project elements will integrate safety systems and equipment during all phases of the project. These systems and equipment include: hazard detection, emergency shutdown, spill containment, fire protection, flooding control, crew escape and safety shelters, and all other safe guarding systems as may be required by federal and international regulations and standards.

The Applicant states that the integrity of the regasification equipment, LNG storage, submerged turret loading (STL) buoys, and pipeline systems will be assured through a formal and documented set of operational procedures, inspections, personnel training, as well as a quality assurance audit and maintenance program. All vessels, pumps, storage tanks, instruments, piping and environmental control equipment are to be inspected and maintained to high standards which will be specified in the final design of the Port Ambrose systems and equipment. All maintenance operations will be performed under strict guidelines designed to minimize risk of releases and to ensure the safety of people and systems.

In addition to the inherent designs and high standards for operational practice, the public, contractors, Port Ambrose personnel, the LNGRVs and the DWP offshore and onshore systems will be protected by comprehensive emergency shutdown systems. Emergency shutdown comprises multiple levels of action from an individual piece of equipment, to shutdown of a system or multiple systems in an area, to an overall facility or project shutdown. The Applicant states that these shutdown systems will be high-integrity, proven technology, and will be redundant systems that can initiate a range of shutdown actions depending upon the cause and nature of the event(s) that produced the emergency condition.

The applicant further states that the safe transfer of natural gas from the LNGRV will be ensured by a series of sensors that provide feedback to the operator panel and that can automatically shutdown gas transfer. Additionally, there are a series of emergency shutdown valves that will also interrupt gas transfer in the event of an unsafe condition along with emergency buoy disconnect procedures for interrupting gas flow as well.

These systems and associated procedures are summarized below and comprise the principal means for dealing with the unsafe discharge of natural gas.

There are three shutdown levels governing the transfer of natural gas from the LNGRV to the STL Buoy:

- Automatic Shutdown (ASD)
- Emergency Shutdown (ESD)
- Emergency Buoy Disconnect (EBD)

The safety related equipment and functions associated with these shutdown levels are described as follows.

Emergency Shutdown (ESD)

ESD is controlled by automatic or manually activated systems:

- Automatic shutdown through the fire and gas detection or other systems on the LNGRV requiring a total shutdown of gas export
- Manual shutdown through ESD buttons positioned at strategic locations

Automatic or manual operation activates closed all of the three ESD valves (ESDV) which are located:

- ESDV1 – ESD valve mounted on main deck upstream of the STL Buoy system
- ESDV2 -- ESD valve mounted in the submerged turret loading (STL) Buoy
- ESDV3 – ESD valve mounted subsea in the pipeline end manifold (PLEM)

The ESD valves are operated by spring return, hydraulically powered actuators with a fail-safe spring return to the closed position. The hydraulic power for operation of the valves is supplied from the STL valve control system. The signal for indicating the open or closed position of the valves will be sent to the vessel control system.

Emergency Buoy Disconnect (EBD)

EBD can only be activated manually through the EBD button located on the STL operator panel on the LNGRVs navigation bridge. EBD involves a shutdown of the gas export operation followed by an automatic disconnection of the STL Buoy. The EBD is initiated through push-button activation in two steps. Step one disconnects the STL gas transfer system while step two releases the STL Buoy. Total time required for the vessel to complete an emergency STL buoy disconnect operation is estimated to be approximately 15 minutes.

Regulatory Vessel Design Requirements[26]

The LNGRVs are designed to be built to comply with the following rules, regulations, and requirements:

- Maritime regulations of the registered country
- International Convention for the Safety of Life at Sea (SOLAS), 1974 with Protocol of 1978, and the amendments up to 2003
- International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code)
- International Convention on Load Lines, 1966 with the Protocol of 1988
- International Convention for Preventing Collisions at Sea, 1972 including amendments of 1981, 1987, 1989 and 1993
- International Tele-Communications Union (ITU) Radio Regulations, 1982

[26] Port Ambrose DWP Application – Volume II, Section 11, Pgs 8-10

- International Convention for the Prevention of Pollution from Ships (MARPOL), 1973 (Annexes I, IV, V and VI (Regulation 12,13, 14 and 16)) with Protocol of 1978 and up to the latest amendments
- MEPC 53/24/Add.2 Proposed Amendments to the Revised MARPOL Annex I
- (Addition of new regulation 13A on oil fuel tank protection) International Convention on Tonnage Measurement of Ships, 1969
- International Labour Conference concerning Crew Accommodation On Board Ship, Convention No. 92 and 133 (except swimming pool)
- ILO Codes of Practice, Safety and Health in Dock Work
- International Electro-Technical Commission (IEC) Publication No. 60092 and International Electro-Technical Commission (IEC) Publication No. 60533 “Electrical and Electronic Installations in Ships-Electromagnetic Compatibility”
- Suez Canal Navigation Regulations and Tonnage Measurement of Ships
- International Convention on Standards of Training, Certification and Watchkeeping (STCW), 1993 and later amendments
- IMO Resolution A.468 (XII) “Code on Noise Levels On Board Ships”, 1981
- IMO Resolution MSC137 (76) “Standards for Ship Maneuverability”
- IMO Resolution A.330 (IX) “Amendment to the Recommendation on Safe Access to and Working in Large Tanks to Include Large Water Ballast Tanks”
- IMO Resolution A601(15) Provision and Display of Maneuvering Information On Board Ships
- IMO Publication No. 978 - Performance Standard for Navigational Equipment
- U.S. Coast Guard’s Regulations for Foreign Flag Vessels Operating in Navigable Waters of the United States (except Alaskan waters, without Certificate or Inspection)
- 33 CFR Part 155: Oil Pollution Prevention Regulations for Vessels
- 33 CFR Part 156: Oil and Hazardous Material Transfer Operations
- 33 CFR Part 159: Marine Sanitation Devices
- 33 CFR Part 164: Navigation Safety Regulation

In addition, the LNGRVs may be subject to the following recommendations and guidelines, as applicable:

- ISO 6954-2000: "Mechanical Vibration - Guideline for the Measurement, Reporting and Evaluation of Vibration with Regard to Habitability on Passenger and merchant ships"
- ISO 8309-1991: Refrigeration Light Hydrocarbon Fluids. Measurements of Liquid Levels in Tanks Containing Liquefied Gases Electric Capacitance Gauges
- U.S. Department of Labor Safety and Health Regulations for Longshoring
- Oil Companies International Marine Forum (OCIMF) “Recommendations on
- Equipment for the Towing of Disabled Tankers,” 1981
- OCIMF “Mooring Equipment Guidelines,” 1997
- OCIMF “Ship to Ship Transfer Guide (Liquefied Gases),” 1995
- OCIMF “Recommendations for Manifolds for Refrigerated Liquefied Natural Gas Carriers (LNG),” 1994
- Society of International Gas Tanker and Terminal Operators (SIGTTO) “Recommendations and Guidelines for Linked Ship/Shore Emergency Shutdown of Liquefied Gas Cargo Transfer,” 1997

- SIGTTO "Recommendations for the Installation of Cargo Strainers on LNG Carriers," 1992
- International Chamber of Shipping (ICS) Guide to Helicopter / Ship Operations
- International Electro-Technical Commission (IEC) Publication 92
- ISO 4406: Hydraulic System Flushing
- VDI 2056 Criteria for Assessment of Mechanical Vibrations in Machines
- IMO Resolution A343(ix) Recommendation on Method of Measuring Noise Levels at Listening Posts
- ISO 8501-1, 1988 (Preparation of Steel Substrates before Application of Paints etc)

The Applicant will be required to comply with applicable codes and standards for the LNGRV safety systems and equipment onboard the vessel. These systems and equipment include: detection, emergency shutdown, spill containment, fire protection, flooding control, crew escape and safety shelters, and all other such equipment as required by applicable federal and international regulations and standards.

Like all LNG carriers, the LNGRVs (membrane and Moss design) will be double-hulled, with the interspaces continuously monitored for leaks. The ships will have cargo surveillance and electronic guidance equipment to ensure the integrity of the LNG cargo.

The LNGRVs will be designed and built under the survey of a selected Recognized Classification Society's (RCS) Rules and IMO Regulations in force at the date of the design contract signing, with the objective of obtaining an IMO Certificate of Fitness.

LNGRVs are designed to carry cryogenic gases and follow stringent International Maritime Organization (IMO) regulations that govern their construction and operation. IMO is an independent organization that provides specific rules for the construction standards for LNG carriers, including safety equipment, marine pollution prevention, operational procedures, and crew training. The IMO conventions, codes, and resolutions that Port Ambrose will follow address the minimum acceptable requirements for such a vessel according to International and U.S. Regulations.

<u>International Labor Organization (ILO)</u>

- ILO Conventions Concerning Crew Accommodation on Board Ships (No. 92&133)

<u>IMO – Conventions</u>

- IMO 110E, International Convention for Safety of Life at sea, 1974 with protocol of 1978/1988 and current amendments (SOLAS)
- IMO 701E, International Convention on Load Lines, 1966 and protocol of 1988 and amendments up to and including the 2003 amendments and later amendments (ICLL)
- IMO 714E, International Convention on Tonnage Measurement of Ships, 1969 as amended by IMO Resolution A.493 and A.494 (XII)
- IMO 904E, Convention on the International Regulations for Prevention of Collisions at Sea (COLREGS) 1972 and later amendments, including IMO Resolution A.464 (XII)

IMO – Codes

- IMO 104E, "International Code For The Construction And Equipment Of Ships Carrying Liquefied Gases In Bulk", International Maritime Organization, 1993 Edition and Supplemental from 1994 and 1996 (IGC Code)
- IMO 116E, "International Ship and Port Facility Safety Code," International Maritime Organization, 2003 Edition (ISPS Code)
- IMO 117E (A), "International Safety Management Code & Revised Guidelines on Implementation of the ISM Code," International Maritime Organization, 2002 Edition (ISM Code)
- IMO 155E, "Fire Safety Systems (FSS) Code," International Maritime Organization, 2001 Edition
- IMO 520E, International Code for Safe Management of Ships and for Pollution from Ships, 1973 (Annex I, IV, V and VI), as modified by the Protocol of 1978 relating thereto and later amendments (MARPOL 73/78)
- IMO 978E, Performance Standards for Navigational Equipment (1997)
- IMO 982E (C), "Life-Saving Appliances," International Maritime Organization, 2002 Edition International Telecommunications Union Radio Regulations 2001 and SOLAS Chapter IV, as amended International Convention on Tonnage Measurement of Ships 1969 as amended by IMO Resolutions and later amendments

IMO – Resolutions

- IMO Resolution A272/A330 "Safe Access to and Working in Large Cargo Tanks and Ballast Spaces"
- IMO Resolution A.343 (IX) "Recommendation on Methods of Measuring Noise Levels at Listening Posts"
- IMO Resolution A.468 (XII) "Code on Noise Levels Onboard Ships"
- IMO Resolution A601 (15) "Provision and Display of Maneuvering Information Onboard Ships"
- IMO Resolution A.686 (17) "Code on Alarms and Indicators"
- IMO Resolution A.708 (17) "Navigation Bridge Visibility and Functions"
- IMO Resolution A719 (17) "Prevention of Air Pollution on Ships"
- IMO Resolution A751 (18) "Interim Standards for Ship Maneuverability"

Compliance with these regulations minimizes the likelihood of an accidental LNG release at the proposed DWP project. Additionally, these safety features would also mitigate any release, regardless of cause. The safety features of the LNGRV for this project are summarized below:

- **Double-Hull Construction**. The IMO/IGC requires LNG carriers to be constructed with an outer and inner hull to provide protection against collisions or groundings and resultant cargo loss. These hulls would be separated from each other by structural members and separated from the cargo by the membrane system. Thus, a collision, grounding, or other impact would need to penetrate up to four layers to result in cargo spillage.

- **Separation of Cargo Holds and Piping Systems**. The IGC requires the structural separation of cargo holds from other spaces as well as separation of cargo piping from other piping systems. This helps keep cargo leaks away from potential ignition sources and keeps cargo from inadvertently being pumped through the wrong pipes.

- **Accessibility for Inspection Access**. The IGC requires that a tank be constructed so that at least one side is visible and accessible to inspectors. This allows proper periodic inspection of the tank for integrity and signs of corrosion or stress.

- **Leak Detectors in Hold Spaces**. The IGC requires that gas detectors and low temperature sensors be placed in a cargo hold in order to detect cargo leakage. An alarm sounds if either is detected and appropriate precautions and mitigation repairs can be made.

- **Tank Requirements for Cargo Containment**. The IGC requires that a tank be constructed with materials that can withstand the temperatures involved so as to properly contain the cargo and have adequate relief valve systems to avoid over pressurization.

- **Structural Analysis**. The IGC requires structural analysis of the cargo containment system and specifies individual tank stress limitations.

- **Secondary Containment and Thermal Management**. The IGC requires partial secondary containment to contain leaks and prevent contact of cryogenic liquid with the inner hull. This prevents thermal stress. In addition, insulation in conjunction with a primary and backup heating system must be installed that would keep the cargo from exceeding the thermal limitations of the material selected for the inner hull if the leak prevention system should fail.

- **Tank Construction and Testing Requirements**. The IGC addresses standards for workmanship, quality, and testing of tanks under construction. Before cargo is pumped aboard, each tank on the LNG carriers would have had its welds nondestructively tested and a pressure test would have been performed to ensure integrity.

- **Isolation, Construction and Testing Requirements for Piping and Pressure Vessels**. The IGC specifies piping thickness, leak testing, pressure testing, isolation requirements, welding requirements, and many other aspects of pressure vessel and piping design and construction. This ensures the integrity of these systems before any cargo is brought aboard.

- **Emergency Shutdown Valves and Shutdown Systems**. The IGC requires remote-control shutdown systems for shutting down cargo and vapor transfer in an emergency. This system must have the ability to be activated from at least two locations on board the LNG carrier and would also be automatically activated in the event of a cargo fire.

- **Pressure Venting Systems**. The IGC specifies that appropriate venting of the cargo be installed to keep the cargo under the design pressure of the tank and keep relief valves from needing to operate

- **Vacuum Protection Systems**. The IGC requires the installation of relief valves that would prevent under-pressurization of cargo tanks in the event that cargo was pumped out without adequately providing for vapor return. The LNG carrier would have sufficient vapor return capacity to keep the pressures at appropriate levels; however, this system would prevent under-pressurization if this system should fail to be actuated or fail to work properly.

- **Fire Protection Systems**. The IGC requires that LNG carriers have a saltwater fire-main system for fighting fires throughout the ship and fixed dry chemical and carbon dioxide systems for cargo areas and compressor rooms, respectively.

- **Water-spray System.** The IGC requires that ships carrying flammable or toxic products or both install a water-spray system for cooling, fire prevention and crew protection to cover exposed cargo tank domes and any exposed parts of cargo tanks; exposed on-deck storage vessels for flammable or toxic products; cargo liquid and vapor discharge and loading manifolds and other areas where control valves are situated; boundaries of superstructures and deckhouses that are normally manned, and other high fire risk items and cargo control rooms.

- **Cargo Tank Instrumentation**. The IGC requires that each cargo tank be outfitted with an integrated instrumentation/alarm system that notifies the crew of possible leaks via gas detection and temperature sensors and tank liquid levels, temperatures, and pressures. These systems, as well as the pressure relief systems mentioned above, provide a many-layered protection against cargo release either through equipment malfunction or human error.

- **Additional Gas Detection Systems**. The IGC requires gas detection systems and alarms in spaces where cargo is located, including compressor spaces, spaces where fuel gas is located, and other spaces likely to contain gasified cargo. Venting systems for certain spaces and portable gas detectors are also required.

- **Automatic Safety Shutdown Systems**. The IGC requires that cargo loading areas and docks be equipped with LNG vapor and fire detection systems that automatically shut down the transfer systems in the event of a leak or fire. Personnel on the loading dock or the LNG carrier can also manually operate these shutdowns.

The technical requirements for vessels to carry LNG in U.S. waters are set forth in 46 CFR Subchapter D and 46 CFR 154. These regulations set forth a comprehensive framework for the certification, inspection and operation of tank vessels carrying LNG in bulk.

In addition to carrying a valid IMO Certificate of Fitness, and complying with the specific U.S. requirements for LNG carriers, foreign-registered LNG carriers operating in U.S. waters must also comply with the following U.S. regulations:

- Pollution prevention regulations (33 CFR Parts 151, 155-157 and 159)
- Navigation safety regulations (33 CFR Part 164)
- Repair regulations (46 CFR Part 35.01-1)

Foreign registered tank vessels must further comply with:

- Cargo venting and handling system requirements (46 CFR Part 35.30 and 35.35)
- Inert gas systems (46 CFR Part 32.53)

- Fire fighting foam systems (46 CFR Part 34-05-5(a)(2))
- Vapor control systems (46 CFR Part 39)

The process-related scenarios identified in the HAZID have not been further analyzed in this study. These scenarios were determined to have smaller potential release sizes (potential breach size, inventory available for release, and duration of release) and a lower potential to escalate (due to the safety and emergency shutdown systems) as compared to other accidental and intentional scenarios for which a detailed examination of the consequences has been performed. The lower likelihood for catastrophic accidental events is based on the codes, regulations, requirements, and additional spill controls to which Port Ambrose has committed for the LNG carriers, the safety record of the LNG industry (both onshore and transportation), and the associated safety features onboard an LNGRV. Therefore, while process releases are credible scenarios, they do not represent the bounding consequence for the range of accidental scenarios identified in the HAZID and have not been included in the IRA as a worst case consequence.

5.1.3 Weather-Related Release

The LNGRVs will monitor current and forecasted weather conditions through regular monitoring of the vessel's equipment (such as radar, barometer, anemometer, and visual observation from the bridge) as well as monitoring National Weather Service internet and VHF voice broadcasts of current and forecasted marine conditions, Dial-A-Buoy service from Station 44065-Entrance to NY Harbor, real-time weather radar satellite imagery via internet, and mass media weather broadcasts available by satellite on the vessel's TV system.

The Port Manager and LNGRV Master at the first sign of significant weather will determine the Master's needs and plans for storm evasion, such that any order to evacuate will be done in a manner timely enough to allow safe weather evasion. Evacuation due to forecasted weather in excess of the limits below will be ordered by the Port Manager in consultation with the LNGRV Master, and in accordance with the COTP New York Hurricane and Severe Weather Plan. Proper notifications and consultations with USCG will be made.

In addition the submerged turret loading (STL) system components are designed for:

- LNGRV to stay connected in the 10-year storm condition
- Idle system will survive the 100-year storm condition

The maximum sea state for connection of a LNGRV to a STL Buoy is:

- Significant wave height (Hs) 9.8 feet (3 m)
- Wind speed (Uw; 1 hour mean) 30 knots (15 m/second)
- Current speed (Uc) 2.9 knots (1.5 m/second)

The HAZID included severe weather at any point along the LNGRV transit and at the DWP. Due to the relatively predictable weather around the port, combined with the robust ship and equipment design, procedures to predict adverse weather conditions, and the ability to disconnect from the buoy should severe weather develop suddenly during transfer operations,[27] significant damage to an LNGRV or the DWP due to severe weather is considered unlikely.

[27] Port Ambrose Application, Vol. III, Sec. 9 (Draft Operations Manual)(Confidential).

5.1.4 Seismic Activity[28]

A system of near vertical normal faults, identified as the New York Bight Fault Zone, is located offshore approximately 9 miles (14.5 km) to the southeast of the city of Long Beach, New York. However, no surface expressions of faults were observed in the data collected during the shallow geophysical survey along the proposed pipeline corridor.

The seismicity of the New York Bight area of the United States has been relatively stable over the past several hundred years, with the earthquake activity being located at a mean depth of approximately 6 miles (10 km). For this reason, and since no active faults were identified during the geophysical surveys, risks to the proposed Project from fault activity are expected to be insignificant.

5.1.5 Aircraft Collision Release

The HAZID considered a large commercial jet, a smaller private jet, or a helicopter colliding with the LNGRV at any point in transit or at the DWP. Since the likelihood of such an accident with an aircraft not associated with the Port Ambrose project is remote, these types of aircraft scenarios have been screened out for further consideration.

5.2 Intentional Release Scenarios

As part of the HAZID, a thorough review of potential intentional attack scenarios against the LNGRV and DWP were developed. These included scenarios required by the USCG to be considered for development of a security vulnerability assessment and facility security plan under the Maritime Transportation Security Act (MTSA) such as standoff attack, ramming, hijacking, and other methods. Describing the weapons, tactics, and potential consequences in detail is not suitable for a public document; therefore, this combination of information is excluded from this report.

The probability of intentional attacks cannot be accurately determined based on historical data. Therefore potential events were not screened out based on any sort of frequency of occurrence. The selection of intentional scenarios for analysis was based solely on events that were deemed to be credible and that bound the potential consequences of a LNG release. Working with Sandia and the USCG, release scenarios have been defined for this risk assessment without associating the weapons or tactics. The intentional acts were evaluated in cooperation with Sandia who had input from local intelligence sources and the most significant of the credible threats identified were analyzed.

5.2.1 Intentional Scenario Breach Sizes

In preparing SAND2008-3153, Sandia met with intelligence agencies and other federal agencies to discuss potential threats against maritime shipping based on the possible capabilities and past actions of politically active groups. From these external and internal discussions with Sandia explosives and threat experts, a set of site-specific threat scenarios was developed to consider against the proposed Port Ambrose operations. As discussed previously, the threat scenarios developed are documented in a separate classified report.

[28] Port Ambrose Application, Vol. II, Section 7 (Public).

Using this set of credible threat scenarios, Sandia performed a series of scoping calculations to estimate the possible breach sizes for a standard membrane-type LNG carrier for this range of threat scenarios. These calculations were conducted using shock physics-based computer models that can calculate the impact of an explosion or an attack with an explosive weapon on a structure, such as a LNG carrier. In SAND2008-3153, Sandia suggested that for the larger 215,000 – 265,000 m^3 LNG carriers where there might be less surveillance or control in an offshore environment, the breach sizes for a range of credible intentional events might vary from 5-12 m^2, with an expected nominal intentional breach size of 12 m^2. Additionally, given that the potential for multiple threats and possible escalating damage to additional tanks from fires or from cryogenic damage from the spilled LNG, Sandia suggested that as many as three LNG tanks may be compromised from a single intentional event.

While these results provide an understanding of the possible range of breach sizes from potential intentional threats, the guidance in SAND2008-3153 suggests that the threat, breach, spill, and hazard analyses should be conducted on a site-specific basis. Therefore, Sandia worked with AcuTech and the USCG to conduct a threat assessment and breach evaluation for specific, credible intentional threat scenarios for the Port Ambrose DWP project. Sandia considered site-specific factors such as ship size and design, LNG volumes, port location, vessel operations, and traffic control and vessel protection to estimate the credible threats and the associated range of possible breach sizes to consider for fire and vapor dispersion hazard distance calculations.

Based on the assessment of these factors for the Port Ambrose DWP location, a range of credible breach sizes was developed for what was considered to be credible threats for this DWP location. While the methodology and breach size results for specific threats are classified, the maximum breach size results estimated for the LNGRV for this project are summarized below.

While the LNGRVs are moored at the Port Ambrose DWP, there is less traffic control, surveillance, and escorts, but the vessels are more difficult to access due to their distance offshore. Taking this into consideration, Sandia recommended the intentional breach sizes for membrane LNGRVs detailed in Table 5-1 be used in calculating LNG spill rates, spill volumes, and associated spill hazards for this project: Since there could be two LNGRVs at the Port Ambrose DWP to provide an uninterrupted flow of natural gas to the pipeline, the impacts of a breach of containment of one LNGRV on a LNGRV at the other buoy location was considered. Also considered was the possibility of a simultaneous attack against two LNGRVs while at the DWP.

Insulation proposed for the LNGRVs could potentially degrade in a fire. While the degradation will be most pronounced at the top of the cargo tanks where there is less shielding of the insulation, the potential of fire damage to additional cargo tanks and cascading spills should be considered. This scenario is represented by Scenarios 2 and 5 and addresses the insulation degradation cascading damage issues.

Table 5-1: Intentional Scenario Summary

Scenario	Description	Event Type
Membrane-Type Carrier - 145,000m^3		
1	One - 16m^2 hole (single cargo tank release)	Intentional
2	Two - 12m^2 holes (two cargo tank release)	Intentional (Cascading Damage)
3	One – 2m^2 hole (single cargo tank release)	Hijacking
4	Two - 5m^2 holes (single cargo tank release)	Hijacking
5	Two - 5m^2 holes (two cargo tank release)	Hijacking (Cascading Damage)

5.3 Vessel Collision Scenario Breach Sizes

Vessel collision had been discussed in the context of both accidental and intentional events. The more extreme result would be associated with an intentional event where no attempt is made to reduce the speed of the striking vessel. However, similar results would be produced by a vessel that is moving at standard speeds but inadvertently strikes an LNGRV calling on the DWP. The analysis performed here addresses both of these potential events.

The severity of a breach from a LNGRV following a collision with another vessel depends on the location of impact, vessel design, relative vessel speeds, collision alignment, and mitigation or prevention systems in place to limit the potential damage. For the Port Ambrose DWP, the applicant is proposing membrane-type LNG carriers. Therefore, this design option has been examined in this section of the IRA to determine the breach size that will be applied in the consequence analysis for the vessel collision scenario.

5.3.1 Calculation of Absorbed Energy

Breaches to membrane-type LNGCs are found to be a function of the kinetic energy of the striking vessel and the energy absorbed by the LNGC. These calculations are applicable to both membrane- and Moss-type LNGCs, as well as the LNGRVs for the Port Ambrose Project, and have been proven in earlier DWP IRAs.

Displacement of the vessels is important and is given by the relationship

$$\text{Displacement} = 1.026 \text{ x } C_b \times \text{Length} \times \text{Breadth} \times \text{Draft}$$

where C_b is the Block coefficient which depends on vessel type as listed in Table 5-2 and the size dimensions are in units of meters.

Table 5-2: Block Coefficient for Various Vessel Types

Vessel Type	C_b
Tanker	0.85
Passenger	0.68
Cargo	0.61
Other	0.75

In calculating the energies, the first key parameters are the mass of the striking vessel (M) and the mass of the struck vessel (m). The total energy associated with the striking vessel is also dependent on the entrained water moving with the vessel. This is related to the mass of the vessel using the parameter D and values of 0.05 to 0.1 are typically used. The mass of the water that is moving along with the striking ship, either by being pushed in front of the vessel or by being dragged along due to friction over the length of the hull. The upper end of the range, specifically a value of 0.1, has been applied in the current calculations.

The absorbed energy is also dependent on the resistive mass that acts on the struck vessel. This can be related as a ratio (d) of added mass relative to the vessel. Minorsky[29] recommended 0.4 times the mass of the struck vessel, and that ratio has been widely used. The initial kinetic energy (E_1) of the striking vessel is correlated to the vessel's initial velocity (V) prior to impact and associated mass through the relation

$$E_1 = ½ (M + DM)V^2$$

For this study it is assumed the struck vessel is initially at rest and assuming a perfectly plastic collision both vessels reach the same final velocity (U) and the initial momentum, given by

$$H_1 = (M + DM)V$$

Equals the final momentum

$$H_2 = (M + DM + m + dm)U$$

conservation of momentum gives H1=H2 which results in

$$U = [(M + DM)/(M + DM + m + dm)]V$$

and the associated final kinetic energy is

$$\begin{aligned} E_2 &= ½ (M + DM + m + dm)U^2 \\ &= ½ (M+DM+m+dm)*[(M+DM)/(M+DM+m+dm)]^2*V^2 \end{aligned}$$

[29] V.V. Minorsky, "An Analysis of Ship Collisions with Reference to Protection of Nuclear Power Plants", Journal of Ship Research, Vol. 3, No. 1 (1959), pp. 1-4.

which simplifies to

$$E_2 = [(M+DM)/(M+DM+m+dm)]*E_1$$

The absorbed energy is the difference in the initial and final kinetic energies and is

$$E_{absorbed} = E_1 - E_2 = \{1-[(M+DM)/(M+DM+m+dm)]\}*E_1$$

5.3.2 Marine Traffic Data

As detailed in Section 5.3.1, the breach size resulting from an impact of a vessel with a LNGRV is a function of the striking ship. This information was made available through AIS data provided by the USCG. Using this information it was possible to establish a range of impact kinetic energies for potential striking ships. This information is summarized in Table 5-3 and will be used in determining the size of breaches due to accidental events.

Table 5-3: Vessel Type and Impact Energy

Vessel Type	Displacement (tonnes)	Max Cruising Speed (knots)	Kinetic Energy (N-m)
Passenger	84 – 127,738	28.1	$6.49 \times 10^5 - 1.11 \times 10^{10}$
Cargo	2,379 – 169,153	24.8	$2.97 \times 10^7 - 1.24 \times 10^{10}$
Tanker	1,744 – 183,141	17.7	$1.51 \times 10^5 - 4.93 \times 10^9$

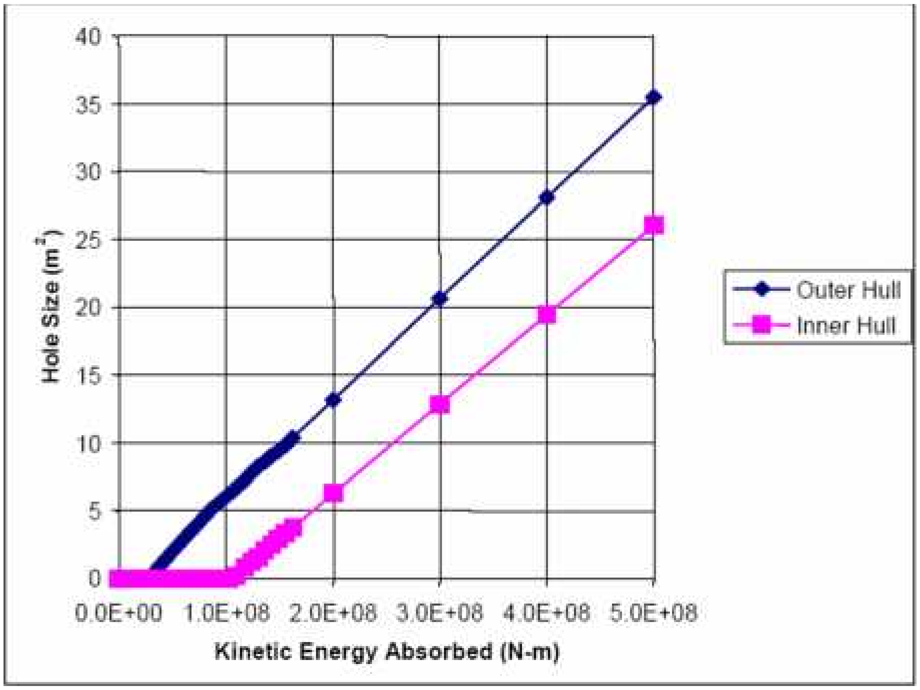
5.3.3 Calculations for Determining Breach Size for a Membrane-Style Cargo Tank

This study uses the approach applied in earlier LNG IRA studies. To fill the void of published work relating damage to LNGCs and LNGRVs (inner hull breach size) to striking vessel type, speed, and energy, Sandia National Labs conducted computational studies. This work included finite element modeling of collisions for a series of double hulled oil tankers, similar in overall size, mass, and design to a membrane-type LNGRV.[30] A result of this analysis is a set of curves useful in estimating the breach size on the outer and inner hull of a membrane-type LNG carrier as a function of the energy of the collision. This relationship, replicated from the Sandia Report, is shown in Figure 5-1.

While membrane-type LNG carriers and crude oil tankers differ, the nature of the double hull vessels are closer in design and response than traditional single hull tankers, where most of the empirical collision data has been obtained. Therefore, the recommendations in SAND2004-6258 were used to assess the expected inner hull breach size for a membrane-type LNGRV following a collision with a passing vessel.

[30] SAND2004-6258 Appendix B

Figure 5-1: Double Hull Tanker Hole Size vs. Kinetic Energy (SAND2004-6258)



The methodology for calculating the size of an inner hull breach in a membrane-type LNGRV (from a vessel-to-vessel collision) was developed with input from the USCG and Sandia, and includes the following steps:

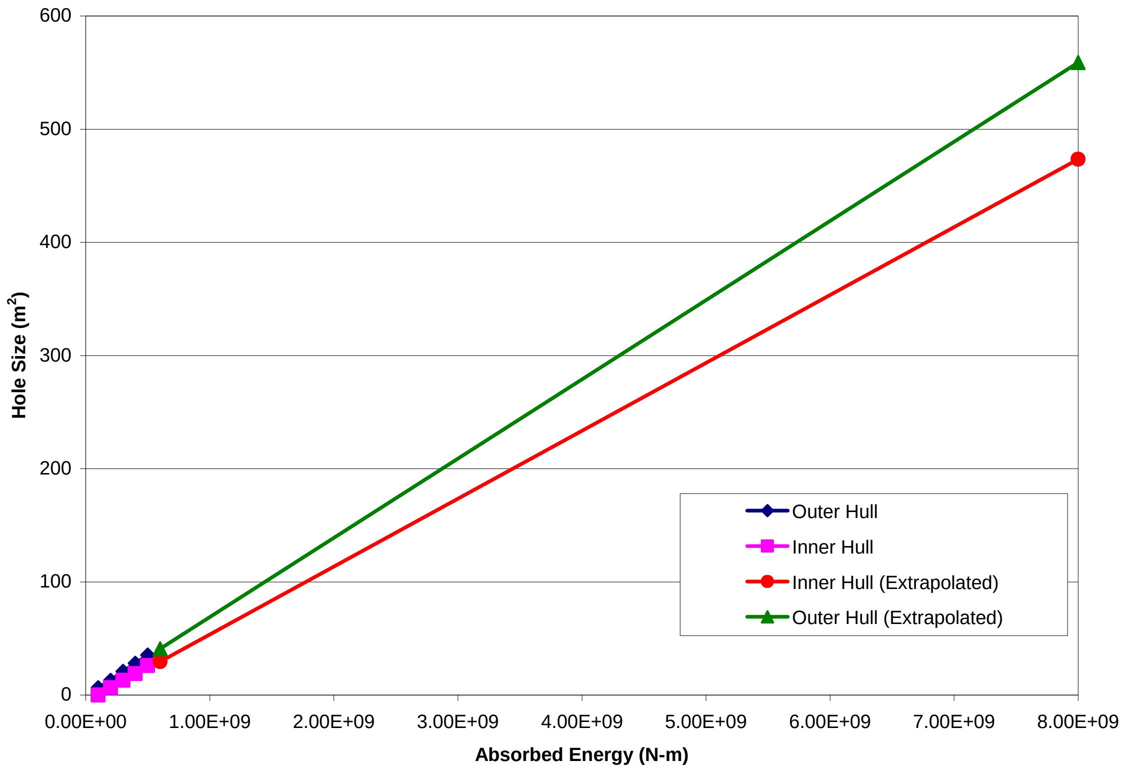
- Calculate the kinetic energy of the vessels with the potential to collide with the LNG carriers for this project. The range of potential vessels is based on the AIS data from the USCG R&D Center, and the kinetic energy is calculated for each striking vessel based on the specific displacement and speed of each vessel.

- Calculate the absorbed energy of the LNGRV based on the kinetic energy of the striking vessel.

- Calculate the final breach size that will be applied in the vessel collision consequence modeling.

Based on discussions with Sandia and the USCG, it was determined that the empirical equations used for ship collisions can be represented as a linear relationship between breach size and absorbed energy. The curves presented in Figure 5-2 were extrapolated by AcuTech (from the data in SAND2004-6258) to determine the breach sizes for collisions with a membrane-type LNGRV.

Figure 5-2: Extrapolated Breach Size vs. Absorbed Energy Curve (Membrane-type LNGC and LNGRV)



Using this information, the methodology for calculating the size of an inner hull breach in a membrane-type LNGRV (from a vessel-to-vessel collision) includes the following steps:

- Calculate the kinetic energy of the vessels with the potential to collide with the LNG carriers for this project. The range of potential vessels is based on the AIS data from the USCG R&D Center, and the kinetic energy is calculated for each striking vessel based on the specific displacement and speed of each vessel.
- Calculate the absorbed energy of the LNGRV based on the kinetic energy of the striking vessel.
- Determine 90th percentile absorbed energy: While the maximum absorbed energy can be calculated, it is only representative of the worst-case or a single and specific vessel transiting near the DWP location. The 90th percentile absorbed energy is a more representative upper bound, eliminating outliers in the upper end of the AIS dataset.
- Extrapolated hole size: Use Figure 5-2 to determine for the 90th percentile absorbed energy the corresponding hole size.

- Calculate the final breach size: The work of Ammerman[31] has been used to support reducing the predicted extrapolated breach size resulting from an accidental collision with LNGRVs[32]. Ammerman's work was originally commissioned to provide a comparative analysis of oil outflow from breached cargo tanks among double hull crude oil carriers. The hypothesis that Ammerman's work supports is that the striking ship remains lodged in the structure of the damaged vessel thus reducing the outflow of cargo. This reduction in extrapolated breach size (a value of 90%) was informally derived from a survey of worldwide tanker collision events. This approach is consistent with Ammerman's double-hull tanker study.

Table 5-4 details the results for the data associated with the proposed Port Ambrose DWP site. The results show that the largest breach size for a collision with a membrane-type LNGRV would be due to a collision with a cargo vessel and would result in a breach size of 23.1 m^2.

Table 5-4: Estimated Vessel Collision Parameters (Membrane LNGRV)

Parameter	Vessel Type			
	Passenger	Cargo	Tanker	Other
Number of Vessels (per year)	107	2,117	1,121	94
Maximum Absorbed Energy (N-m)	5.63×10^9	6.05×10^9	2.16×10^9	2.45×10^9
90^{th} Percentile Absorbed Energy (N-m)	3.96×10^9	3.45×10^9	1.64×10^9	4.31×10^8
Extrapolated Hole (m^2)	231	200	92	18
Breach Size (m^2)	23.1	20.0	9.2	1.8

In these calculations, only the three vessel types (passenger, cargo, and tanker), and only those vessels within this subset with the appropriate combination of displacement and speed have been included in the estimation of the resultant collision breach size of a membrane-type LNGRV. Therefore, any vessels from the AIS dataset passing the DWP location with an absorbed energy of less than 1.0×10^8 N-m are not included, as these would not result in a calculated inner hull breach[33]. This minimum absorbed energy for inner hull damage is illustrated in Figure 5-1.

While there is a potential for post panamax vessels entering the NYNJ in the future, given the low number of LNGRV receipts to Port Ambrose (up to 45 per year) and low number of future post panamax vessels entering NYNJ port, the probability of their collision with an LNGRV is extremely remote. Additionally, as the 90th percentile absorbed energy which is a more representative upper bound, is used to determine the release size from a collision with the LNGRV (as compared to the maximum energy), no significant difference in maximum breach size is expected. Therefore, post panamax vessels are not considered in the collision analysis.

[31] Ammerman, D.,"Marine Safety Systems, Control Ballast Tanker Interactive CD," SAND2002-3188P, (Albuquerque, NM: Sandia National Laboratories, 2002).
[32] SAND2004-6258.
[33] It is possible that there may be two LNGRVs at the Port Ambrose DWP simultaneously to ensure constant natural gas supply. These LNG vessels do not have sufficient kinetic energy at their approach speed within the safety zone to result in an inner hull breach if a collision between two LNG project vessels were to occur. Therefore, the LNGRVs have been screened out from further consideration in these calculations.

6.0 Vessel Collision Frequency Analysis

This section focuses on the frequency of collisions between ships and between ships and a fixed object. A ship striking a fixed object is formally referred to as an allision. Although LNG regasification vessels (LNGRVs) moored at the deepwater port (DWP) buoys can weathervane with the wind and current, they are not underway while unloading at a DWP. Nevertheless, for the purposes of this analysis, a ship striking a moored LNGRV will be referred to as a collision.

A powered collision for the Port Ambrose project may involve:

- Collisions between an LNGRV and ships transiting near the proposed DWP (typical associated with New York Harbor) and under way.

A drifting collision may involve any of the following:

- Collisions between an LNGRV and ships transiting near the proposed DWP (typical associated with New York Harbor) that loses steerage.

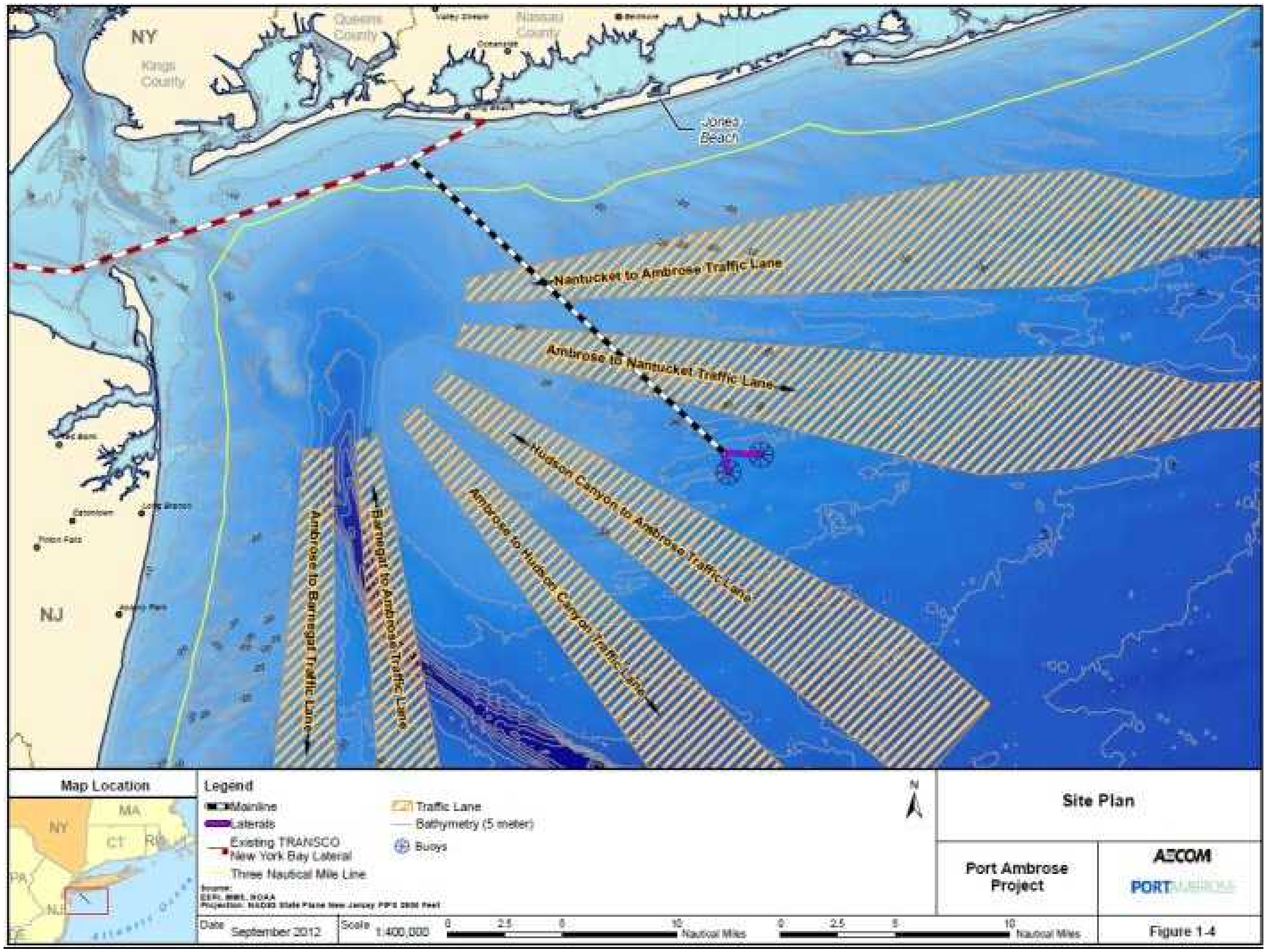
Passing vessel collisions for the Port Ambrose project can be divided into two categories. The first category is for vessels transiting in defined routes (or shipping lanes), represented by vessels that use the Ambrose to Nantucket line and the Hudson Canyon to Ambrose lane. The second category is for randomly distributed vessels near the DWP.

The vessel fairways are presented in Figure 6-1, with the Port Ambrose DWP located approximately 3.3 nautical miles from the center (2.0 nautical miles to the edge) of the Ambrose to Nantucket lane, and 3.7 nautical miles from the center (2.9 nautical miles from the edge) of the Hudson Canyon to Ambrose lane.

Vessel traffic data to be used in the analysis was provided by the U.S. Coast Guard (USCG) R & D Center. The data is the Automatic Identification System (AIS) which provides the vessel details in terms of size and the location and speed. This data is used to establish the traffic distribution for use in the analysis of powered collision by vessels in the shipping lanes.

The AIS dataset for this project indicates that there are vessels that pass the proposed DWP location, but do not use a defined route (a formal or informal shipping or transit lane). Additionally, the data indicates that some of these vessels do have sufficient displacement and speed to result in an inner hull breach of the LNGRV in a collision. Therefore, the frequency of these vessels colliding with an LNGRV at the DWP has been evaluated as part of this analysis.

Figure 6-1: Port Ambrose Buoy Locations and Safety Fairway



6.1 Collision Analysis

The AIS data that was collected for the Port Ambrose project area included not only all vessel traffic, but also data to identify vessels with sufficient displacement, speed, and kinetic energy to breach the inner hull of a LNGRV. Section 5 presents the LNGRV inner hull damage calculations for vessel collisions. As detailed in this section, only vessels with the combination of displacement and speed that can result in an absorbed collision energy with the LNGRV of 1.0×10^8 N-m or greater have the potential to breach the inner hull of the LNGRV. This level of absorbed energy is the minimum required to breach the hull of a membrane-style LNGRV. The remaining vessels[34] are assumed to be incapable of causing an inner hull breach of the LNGRV, and a collision with these vessels is assumed not to result in a release of LNG.

Using the subset of AIS data (vessels with absorbed collision energy of 1.0 x 10 N-m or greater), there are 3,702 annual vessel movements in the defined lanes to the north and south of the proposed Port Ambrose DWP. Of these annual vessel movements, 1,794 vessels were traveling in the Ambrose to Nantucket lane and 1,908 vessels were traveling in the Hudson Canyon to Ambrose lane. All of these vessel movements have the potential to breach the inner hull of the LNGRV at cruising speed.

Given the low number of LNGRV receipts to Port Ambrose (up to 45 per year) and low number of future post panamax vessels, additional post panamax vessels is not expected to have a significant impact to the vessel collision frequency analysis.

6.1.1 Powered Collisions

The frequency of powered collisions is given as follows. This model was developed by DNV and has been used for ship collision analyses for DWP application IRAs over the past four years.[35] .

$$F_{power} = N \times P_{coll} \times P_2 \times P_3$$

Where:
F_{power} = Frequency of powered collision, per year
N = Number of transits in safety fairway or other route, per year
P_{coll} = Probability of collision
P_2 = Probability of steering system failure when on collision course = 2.0×10^{-4}
P_3 = Probability of failure to recover from collision course given a warning from moored LNGRV = 0.67

The selection of the probability distribution function (P_{coll}) depends on the route followed by the vessels transiting past the LNGRV. Since the powered collision is only considering vessels in the Ambrose to Nantucket lane and the Hudson Canyon to Ambrose lane, the vessels in the safety fairway can be represented as a skewed normal distribution between each fairway and the DWP.

[34] In the future, it is possible that there may be up to two LNGRVs at the Port Ambrose DWP simultaneously to ensure constant natural gas supply. These LNG vessels do not have sufficient absorbed energy at their approach speed within the safety zone to result in an inner hull breach if a collision between two LNG project vessels were to occur. Therefore, the LNGRVs have been screened out from further consideration in these calculations.

[35] Det Norske Veritas (DNV), *Concept Safety Assessment of LNG Floating, Storage & Regasification Unit (FSRU)*. Final Report, March 14, 2003, Project No. 230-11749.

There are many skewed continuous distribution functions that can be used to model the vessel routes. After reviewing these, the Rayleigh distribution function was selected for its simplicity. It is defined with only one parameter, namely the mode, *b*. For application to vessels in the safety fairway, a value of *b* of 0.5 nm was selected, and is consistent with an assumption that vessels could deviate up to one-half mile to pass other vessels, or that the vessels may drift within the safety fairway since it is not a defined traffic separation scheme (TSS).

The Rayleigh probability density function is P(r):

$$P(r) = \frac{r}{b^2}\exp\left[-0.5\left(\frac{r}{b}\right)^2\right]$$

The cumulative distribution function is D(r):

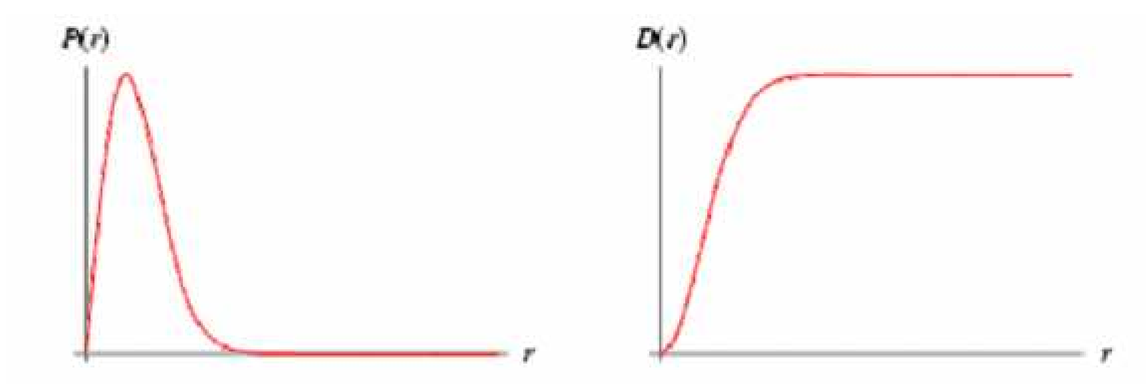
$$D(r) = 1 - \exp\left[-0.5\left(\frac{r}{b}\right)^2\right]$$

Where:

- D(r) = Cumulative distribution function
- r = Distance from the DWP buoys to marine traffic track or lane (when measuring distances to the safety fairway, the distance from the DWP to the edge of the AIS identified vessels in the fairway was used)
- b = Mode value of distribution = 0.5 nm

The form of the Rayleigh distribution function is shown in Figure 6-2.

Figure 6-2: Rayleigh Probability Density and Cumulative Distribution Functions



To determine the probability that a LNGRV will be within the distance defined by the mode of the distribution (i.e., 0.5 nm), the value of D(r) must be calculated for two distances: the distance from the moored LNGRV to the safety fairway or track plus half the length of the LNGRV, and the distance from the moored LNGRV to the safety fairway or track minus half the length of the LNGRV.

Therefore, the two distances are:

$$r_1 = r + 0.5(\text{length of LNGRV})$$

$$r_2 = r - 0.5(\text{length of LNGRV})$$

The length of the LNGRV is 280 m. Once D (r_1) and D (r_2) are determined, the probability of collision is the difference between these two values:

$$P_{coll} = D(r_1) - D(r_2)$$

Table 6-1 shows a summary of the P_{coll} calculations for the DWP locations with respect to the Ambrose to Nantucket lane (North Fairway) and Hudson Canyon to Ambrose lane (South Fairway). As shown in Table 6-2:

- Probability of powered collision with Buoy #1 = 8.00 x 10^{-9}
- Probability of powered collision with Buoy #2 = 2.31 x 10^{-5}
- Probability of powered collision with DWP = 2.13 x 10^{-5}

Table 6-1: Summary of Calculated Pcoll Values[36]

DESCRIPTION OF DWP BUOY & TRAFFIC LOCATION	DISTANCE FROM DWP BUOY TO SAFETY FAIRWAY/ROUTE, r (nm)	r_1 (nm)	r_2 (nm)	D(r_1)	D(r_2)	P_{COLL}
Buoy #1 (to North Fairway)	3.5	3.575594	3.424406	1	1	5.74 x 10^{-11}
Buoy #1 (to South Fairway)	3.0	3.075594	2.924406	1	1	3.12 x 10^{-8}
Buoy #2 (to North Fairway)	2.2	2.275594	2.124406	0.99996	0.99988	8.84 x 10^{-5}
Buoy #2 (to South Fairway)	4.5	4.575594	4.424406	1	1	0

Table 6-2: Summary of Frequencies of Powered Collisions

DESCRIPTION OF DWP BUOY & TRAFFIC LOCATION	N	P_{COLL}	P_2	P_3	F_{POWER}
Buoy #1 (to North Fairway)	1,794	5.74 x 10^{-11}	2.00 × 10^{-4}	0.67	1.38 x 10^{-11}
Buoy #1 (to South Fairway)	1,908	3.12 x 10^{-8}	2.00 × 10^{-4}	0.67	7.98 x 10^{-9}
Buoy #2 (to North Fairway)	1,794	8.84 x 10^{-5}	2.00 × 10^{-4}	0.67	2.13 x 10^{-5}
Buoy #2 (to South Fairway)	1,908	0	2.00 × 10^{-4}	0.67	0

[36] Based on the calculations performed for the Table 6-1 values, it is clear that for any value of r that is greater than 4.0 nm, the values of D(r_1) and D(r_2) become so small (< 1 X 10^{-12}) that the value of P_{coll} approaches zero. Therefore, for any combination of vessels either in the vessel safety fairway or at a distance of more than 4.0 nm, the probability of collision is calculated as zero.

6.1.2 Drifting Collisions

Drifting collisions are possible at the proposed DWP location if a vessel in the safety fairway loses propulsion and the wind and current cause the damaged vessel to collide at low speed with a moored LNGRV. As with powered collisions, the only vessels of concern are those with the requisite mass at the assumed drifting speed that have enough kinetic energy to possibly breach the inner hull of a LNGRV. The drifting speed of a vessel is dependent on the vessel type/size and the wind speed.[37] The weather at the DWP location was evaluated by reviewing data from the National Oceanic and Atmospheric Administration (NOAA), National Buoy Data Center. Specifically for this Port, data from Station 44025 – Long Island – 30 NM South of Islip, NY was collected and reviewed. The prevailing wind speed at the DWP is 10 m/s (19.4 kts). This wind speed translates into a Beaufort Wind Strength of 6[38], and for the larger passenger, cargo and tankers operating near the DWP, a drifting speed of 1.7 kts is applied for this analysis. Using the displacement data from the AIS and a speed of 1.7 kts, there are no vessels surrounding the Port Ambrose area of operation that have the potential to breach the inner hull of a LNGRV in a drifting collision. Specifically, there is no vessel of sufficient displacement drifting at a speed of 1.7 kts that would result in an absorbed energy of 1.0×10^8 N-m or greater. Based on these results, the frequency of a drifting collision between a vessel in the safety fairway and an LNGRV at the DWP is not considered.

6.1.3 Randomly Distributed Vessels

The underlying technical basis for the collision frequency for randomly distributed vessels was published by DNV (2003).[39]

As discussed, the AIS dataset for this project shows vessel traffic near the proposed DWP with no defined routes. Additionally, there is a subset of these randomly distributed vessels that have sufficient displacement and cruising speed to result in an inner hull breach of the LNGRV in a collision.

In this analysis, the vessel traffic with a collision absorbed energy potential of 1.0×10^8 N-m or greater is defined in terms of a density (i.e., the number of vessels per square nautical mile). The collision frequency model for random vessel motion is outlined below.

$$F_{random} = N \times P_1 \times P_2 \times P_3$$

Where:
$N = \rho \times \pi \times R^2$ = the number of vessels within a circle with radius R
ρ = density of vessels (vessels/m^2)
$R = 365 \times 24 \times 3600 \times V$ = the distance traveled in one year
V = vessel speed (m/s)
$P_1 = D/(\pi \times R)$ = the mean geometric collision probability
D = collision diameter of the LNGRV (m)
P_2 = probability of loss of control onboard the ship
P_3 = probability of failure of warning or diverting a ship on collision course

[37] Centre for Marine and Petroleum Technology (CMPT), "A Guide to Quantitative Risk Assessment for Offshore Installations," 1999.
[38] http://www.spc.noaa.gov/faq/tornado/beaufort.html
[39] DNV Project No. 230-11749, 2003.

For this calculation, the values for P_2 and P_3 are the same as for the powered vessel collision calculation, Section 6.1. Specifically:

- $P_2 = 2.0 \times 10^{-4}$
- $P_3 = 0.67$

From the AIS dataset, it can be assumed that vessels with sufficient displacement to breach the inner hull of the LNGRV could be passenger vessels, cargo vessels, or tankers. The average cruising speed for these vessel types, at this distance from shore, is approximately 12.2 kts (6.3 m/s).

Evaluating the vessel traffic around the DWP for vessels with the potential to breach the inner hull of the LNGRV in a collision:

- Buoy #1: There are approximately 223 vessels (between the defined shipping lanes) in a given year (density = 1.21×10^{-5} vessels/ meter^2)
- Buoy #2: There are approximately 144 vessels (between the defined shipping lanes) in a given year (density = 5.57×10^{-6} vessels/ meter^2)

Since these vessels can approach the DWP from any direction, the collision diameter (D) of the LNGRV is equal to the average apparent width of the LNGRV.

$$D = (\text{Length} + \text{Beam}) \times 2 / \pi$$

Given an LNGRV length of 280 meters and a beam of 43 meters, D is calculated to be 205.6 meters.

Using the collision frequency calculation above, and the listed assumptions, the collision frequency for vessels randomly passing the DWP is calculated to be 1.67×10^{-8} collisions per year (one collision that could result in an inner hull breach of the LNGRV every 59,862,372 years). It should be noted that this frequency does not take into account any safety and security zones and or ATBA that may be established as part of the DWP. In addition to collision detection and avoidance systems that may be placed on both the LNGRV and the potential colliding vessel, the actual likelihood of a vessel collision with an LNGRV at the DWP by a passing vessel would be expected to be much lower than calculated.

6.2 Final DWP Collision Frequencies

The final frequencies for collisions between various deep draft vessels transiting the New York Harbor area and LNGRVs moored at the Port Ambrose DWP locations are shown below.

The total frequency of a collision with an LNGRV at the DWP was calculated for two vessel types: 1) vessels in the established Ambrose to Nantucket lane and Hudson Canyon to Ambrose lane; and 2) vessels randomly passing the DWP location. This calculation utilized vessel traffic from the AIS dataset for this project and only included those vessels with the potential to breach the inner hull of the LNGRV in a collision. Table 6-3 shows the summary of the annual collision frequency for the DWP location.

Table 6-3: Frequency of Vessel Collisions for Proposed DWP

TRAFFIC LOCATION	ANNUAL FREQUENCY OF COLLISION (COLLISION PER YEAR)	COLLISION ESTIMATED PERIOD (YEARS PER COLLISION)
Ambrose to Nantucket Lane	2.13×10^{-5}	1 collision every 47,000 years
Hudson Canyon to Ambrose Lane	7.98×10^{-9}	1 collision every 125,000 years
Randomly Distributed	1.67×10^{-8}	1 collision every 60,000 years
TOTAL	$\mathbf{2.13 \times 10^{-5}}$	**1 collision every 47,000 years**

7.0 Consequence Analysis

This section includes a discussion of the modeling approach to the consequence analysis as well as a discussion of the modeling parameters and bounding conditions applied to the models.

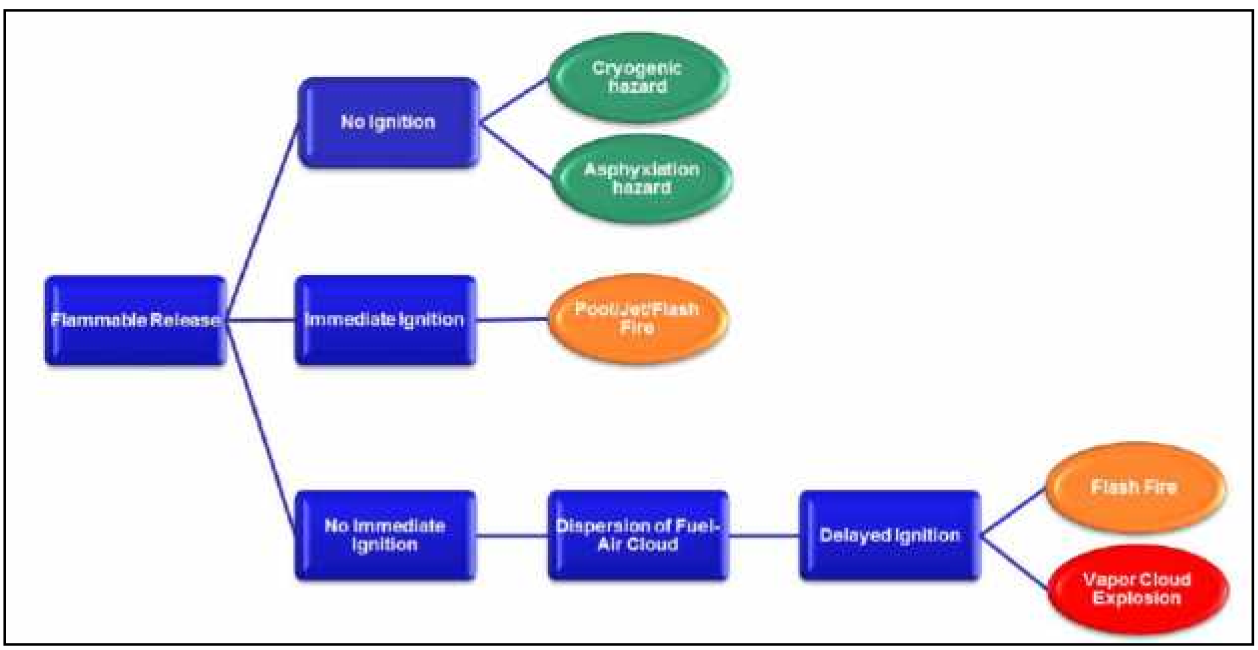
The LNG spill scenarios were modeled using the tools (computational fluid dynamics and solid flame models) required by the USCG Guard for this type of analysis. In particular, the FLACS computational fluid dynamics (CFD) tool was used to determine LNG pool spreading and vaporization and LNG vapor dispersion. A solid-flame model based on calculations performed by FERC staff was used for the thermal radiation calculations, and the pool fire radiant heat flux hazard distance analysis was performed according to the parameters specified by Sandia following their large scale LNG pool fire experiments.

Conservative assumptions were made throughout the analysis, to increase the margin of safety in the simulations.

7.1 Scope

The scope of the consequence analysis for this Independent Risk Analysis (IRA) is to estimate the thermal radiation and flammable vapor dispersion hazards from the accidental and intentional release scenarios developed in Section 5. The impacts that are evaluated for these hazards are consistent with injuries to humans and damage to property. A large scale release is defined as any release of LNG in which the spilled LNG volume and flow rate are greater than those obtained from process systems failures (e.g., pipe or valve failures). Figure 7-1 shows the event tree following a large scale release of LNG over water.

Figure 7-1: Event Tree for a Large-scale LNG Release over Water



Of the four potential consequences of an LNG release shown in the event tree (i.e., pool fire, flash fire, vapor cloud explosion and no event), the thermal radiation hazard zones from pool fires and the flammable vapor dispersion that defines the extent of a flash fire are specifically addressed in the IRA. These consequence types have the potential to impact the public surrounding the deepwater port (DWP). The reasons the other consequence types are not specifically addressed in a DWP IRA are:

- Vapor Cloud Explosion: The release of a flammable material may lead to a vapor cloud explosion if ignited. A vapor cloud explosion results from the rapid combustion of a fuel/air cloud with the flame speed approaching sonic velocity, thereby producing a blast wave. Turbulence is required for the acceleration of flame front to speeds required to produce the blast overpressure associated with an explosion. In the absence of turbulence, a flash fire will occur without any appreciable overpressure. Flame turbulence is typically formed by the interaction between the flame front and obstacles. For this DWP location, vapor cloud explosions are not considered likely, given the absence of other structures that could provide confinement of the flammable vapor cloud.
- Cryogenic: Defined as a "no event" in Figure 7-1, cryogenic contact hazards are limited to areas that can be reached by the LNG pool. Based on available pool size estimates,[40] cryogenic contact hazards are not expected to extend far enough from the proposed project to affect the public.
- Asphyxiation: Defined as a "no event" on Figure 7-1, a risk of asphyxiation from LNG vaporization may be present if the gas concentration is sufficiently high to reduce the oxygen concentration below tolerable levels. A literature review by Sandia[41] indicates minimal frequency of permanent injury to the general population for oxygen levels above 14%. As the vapor cloud disperses away from the LNG pool, the gas concentration decreases and so does the risk of asphyxiation. Since the public will not be allowed within the Safety Zone around the LNGRV, asphyxiation hazards to the public are not considered to be an issue in this study.

7.2 FLACS Model

The LNG vapor dispersion calculations included in this report were performed using GexCon's CFD modeling software FLACS. FLACS is a widely used computational fluid dynamics (CFD) model, which has been extensively validated for the dispersion of LNG and other dense vapor clouds, additional details on the FLACS CFD model are provided below. The thermal radiation calculations were performed using a solid flame-based pool fire model, which utilizes correlations based on experimental data published in the Society of Fire Protection Engineers' (SFPE) Handbook of Fire Protection Engineering.[42]

FLACS, developed and maintained by GexCon AS in Norway, is a computational fluid dynamics (CFD) tool to model ventilation (i.e., natural or mechanical air flow), gas dispersion, gas/vapor cloud explosions and blast propagation in three-dimensional geometries, such as complex process areas.

A two-dimensional shallow water-based model was developed a few years ago to simulate the spreading and vaporization from liquid spills (e.g., from LNG releases). The 2D pool model is fully coupled with the 3D atmospheric dispersion model, resulting in a unified environment in which the

[40] SAND2004-6258.
[41] Ibid., pg. 117.
[42] SFPE Handbook of Fire Protection Engineering, 3rd Edition, edited by P. DiNenno, National Fire Protection Association, Quincy, MA (2002).

entire scenario (liquid spill and vapor dispersion) can be simulated efficiently and accurately. The pool model in FLACS is based on the well-established shallow water model,[43] which assumes that the pool thickness is much smaller than its horizontal dimensions; in that case, all properties of the pool (temperature, density, velocity, etc.) can be approximated as locally uniform over the thickness for the liquid layer. The FLACS pool model thus allows for the formation and spreading of the pool, accounting for the presence of obstacles and sloped terrain. The time-dependent evaporation rate is calculated locally (grid cell by grid cell) and is the sum of contributions from heat transfer from the substrate (ground or water), solar radiation and convective heat transfer.[44] The rate of vapor generation is also affected by physical variables such as local wind speeds and turbulence levels, as well as the local vapor pressure above the pool, all of which can be calculated at every time step due to the simultaneous solution of both the liquid pool spread and the vapor cloud dispersion.

Model validation has been a critical component of FLACS development since its inception.[45] As a result, a large database of FLACS validation examples currently exists which includes gas dispersion[46,47] and vapor cloud explosion experiments,[48] spanning from laboratory-scale to full-scale experiments performed by several different groups. Several of the validation studies, particularly the most recent ones, consist of blind validation exercises (i.e., the simulations were performed prior to or without knowledge of the experimental results) and demonstrate the ability of FLACS software to accurately predict gas dispersion and explosion scenarios without “tweaking”.

7.3 LNG Release Scenarios

As detailed in Section 5, a subset of the release scenarios based on the HAZard IDentification (HAZID) process, led by AcuTech, were selected for inclusion in the risk assessment. The identified scenarios represent the worst credible scenarios, or the bounding scenarios. These scenarios lead to large scale releases of LNG from either a 145,000 m^3 membrane-style LNGRV:

- Scenario 1: Intentional attack leading to a 16 m^2 breach in a single tank
- Scenario 2: Intentional attack leading to a 12 m^2 breach in two (2) tanks
- Scenario 3: Hijacking attack leading to a 2 m^2 breach in a single tank
- Scenario 4: Hijacking attack leading to a 5 m^2 breach in a single tank
- Scenario 5: Hijacking attack leading to a 2 m^2 breach in two (2) tanks
- Scenario 6: Vessel collision/allision leading to a 23.1 m^2 breach in a single tank

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[43] Fannelop, T. K., & Waldman, G. D. (1971). Dynamics of oil slicks. AIAA Journal, 10, 506-510

[44] Hansen, O. R., Melheim, J. A., & Storvik, I. E. (2007). CFD-modeling of LNG dispersion experiments. In AIChE spring national meeting, 7th topical conference on natural gas utilization, Houston, USA

[45] Hjertager, B.H., Bjørkhaug, M., Fuhre, K. (1988). Gas explosion experiments in 1:33 scale and 1:5 scale; offshore separator and compressor modules using stoichiometric homogeneous fuel–air clouds. J. Loss. Prev. Process Ind. 1, 197–205

[46] Venetsanos, A. G., Papanikolaou, E., Delichatsios, M., Garcia, J., Hansen, O. R., Heitsch, M., et al. (2009), “An intercomparison exercise on the capabilities of CFD models to predict the short and long term distribution and mixing of hydrogen in a garage,” International Journal of Hydrogen Energy 34(14): 5912–5923

[47] Middha, P., Ichard, M. & Arntzen, B. (2010). Validation of CFD modelling of LH2 spread and evaporation against largescale spill experiments. International Journal of Hydrogen Energy, 36: 2620-2627

[48] Hjertager, B.H., Bjørkhaug, M., Fuhre, K. (1988). Explosion propagation of nonhomogeneous methane-air clouds inside an obstructed 50 m3 vented vessel. J. Haz. Mater. 19, 139–153

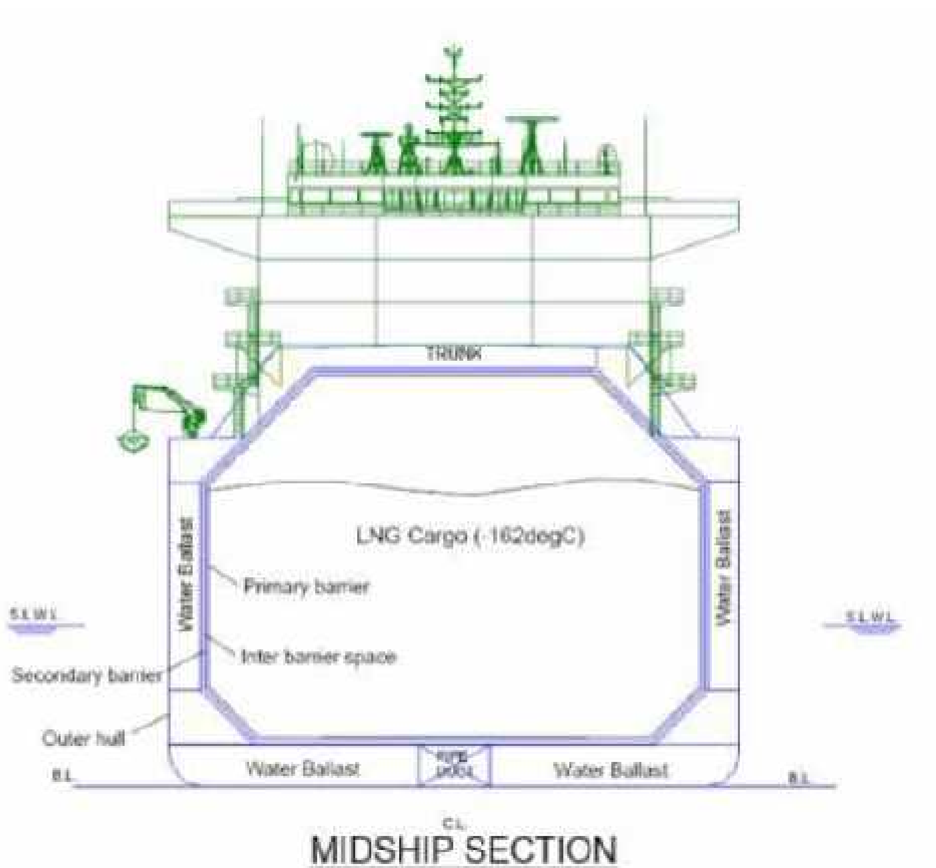
The outcome of the consequence assessment for each of these scenarios will be affected by the choice of the modeling tools as well as of the numerical values used for the various parameters, such as ambient conditions, that affect the modeling results. This section discusses some of the assumptions made in this study, as well as the parameter values used in the analysis, with the basis for their selection.

The scope of the consequence modeling does not include an estimate of the probability of occurrence of any one of the above four scenarios.

7.3.1 Breach Locations

The total volume of LNG spilled as well as the flow rate of LNG through a tank breach in a LNG regasification vessel (LNG RV) depends on the location of the hole. The LNG spill volume and flow rate are maximum for holes at the waterline – in fact, if the hole is below the waterline, the flow of LNG out of the tank is decreased by the backpressure caused by the water above the hole (water is heavier than LNG and therefore the hydrostatic pressure outside the hole grows faster than inside the hole), as well as by the flow of water into the tank. Other phenomena, such as ice formation around the hole and increased LNG vaporization as the spill flows towards the water surface, are also likely to result in overall smaller LNG pools for an underwater release, and consequently, smaller hazards to the public. Therefore, the conservative approach in all scenarios considered in this study is to assume that the tank breach occurs at the waterline, as shown in Figure 7-2.

Figure 7-2: Cross-section of Typical Membrane-type LNGRV Tank



7.4 Selection of Modeling Parameters

Physical parameters, such as the LNG composition and the atmospheric conditions, affect the physical mechanisms that control events such as the formation and dispersion of an LNG vapor cloud or the size, duration and intensity of an LNG pool fire. These parameters need to be defined before the consequences of a large LNG release scenario can be quantified.

7.4.1 LNG Composition

LNG is typically composed primarily of methane (approximately 90 – 95%), with smaller fractions of heavier hydrocarbons (ethane, propane, butane, etc.). Methane is the most volatile compound in the LNG mixture, with a boiling temperature of approximately -261°F or -162°C (ethane, the next most volatile compound, has a boiling temperature of -87°C). Therefore, the vapor clouds formed from an LNG pool over water will contain primarily methane until most of the methane has evaporated and the pool has reduced to a fraction of the original volume. Similarly, in the event of an LNG pool fire, methane gas will be the primary fuel until most of the methane has been consumed and the pool has reduced to a fraction of the original volume. This study assumed LNG to be composed of 100% methane.

7.4.2 Ambient Conditions

Ambient conditions that affect the flammable vapor cloud dispersion and heat flux hazard distances include: air temperature and relative humidity, atmospheric stability, wind speed and water temperature. Other parameters that could affect the LNG pool or vapor cloud, such as waves, currently lack established modeling options and thus were not included in this study.

There are currently no regulations for offshore LNG terminals that specify which ambient conditions should be used for LNG hazard calculations. Federal regulations for land-based LNG terminals list specific requirements for the ambient conditions to be used in thermal radiation and flammable vapor dispersion hazard distance calculations. These requirements can be used as reference to select the parameters for this study. For thermal radiation calculations, 49 CFR 193.2057 states that:

- The wind speed producing the maximum exclusion distances shall be used except for wind speeds that occur less than 5% of the time, based on recorded data for the area.
- The ambient temperature and relative humidity that produce the maximum exclusion distances shall be used except for values that occur less than 5% of the time, based on recorded data for the area.

For flammable vapor dispersion calculations, 49 CFR 193.2059 states that:

- Dispersion conditions are a combination of those which result in longer predicted downwind dispersion distances than other weather conditions at the site at least 90% of the time, based on figures maintained by the National Weather Service of the U.S. Department of Commerce, or as an alternative, where the model used gives longer distances at lower wind speeds.
- Atmospheric Stability (Pasquill-Gifford Class) "F".
- Wind speed = 2.01 meters/sec (4.5 miles per hour, or 3.9 knots).
- Wind speed reference height = 10 meters.

- Relative humidity = 50%.
- Atmospheric temperature = average in the region.

Approximately four years worth of meteorological data from buoy station No. 44025 were used to select realistic ranges of the parameters to be tested.[49] Buoy station No. 44025 is located approximately 30 nautical miles south of Islip, New York, and thus in proximity of the Project. Based on the buoy data, the ambient conditions selected for the Port Ambrose DWP location are detailed in Table 7-1.

Table 7-1: Modeling Parameters

Parameter	Vapor Dispersion Modeling	Thermal Radiation Modeling
Ambient Air Temperature	13.5°C (85°F)	-0.2°C (28°F)
Ambient Relative Humidity	50% [50]	5%
Wind Speed (at 10 m elevation)	2.0 m/s (3.9 knots)	10.0 m/s (19.4 knots)
Atmospheric Stability Class	F	-
LNG Composition	100% Methane	-
Ground Roughness	0.0002 meters	-

Note that the wind was assumed to be parallel to the vessel, from stern to bow. The wind direction – relative to the vessel – should be expected to have some effect on the dispersion of the vapor cloud. However, since the vessel will be weathervaning, the wind direction will be aligned with the vessel (or within a small angle – e.g., +/- 15 degrees) the majority of the time. Additionally, the LNG carrier represents a small obstacle to the wind flow, when compared with the size and downwind dispersion of the LNG vapor cloud.

7.4.3 LNG Pool Spreading and Vaporization Rate

The FLACS software package includes a model to calculate the spreading and vaporization of LNG (or other liquid) spills onto water (or other substrates). The FLACS pool model is based on the Shallow Water equations and has been validated against available data, as described in Section 7.2. For spills onto water, the FLACS pool model calculates the vapor generation within each grid cell according to the convective heat transfer equation:

$$M = \frac{Q}{\lambda} = \frac{h * A * (T \quad - T \quad)}{\lambda}$$

Where:

- M is the vapor generation per unit time;
- Q is the heat transfer to the pool;
- λ is the latent heat of vaporization of LNG;

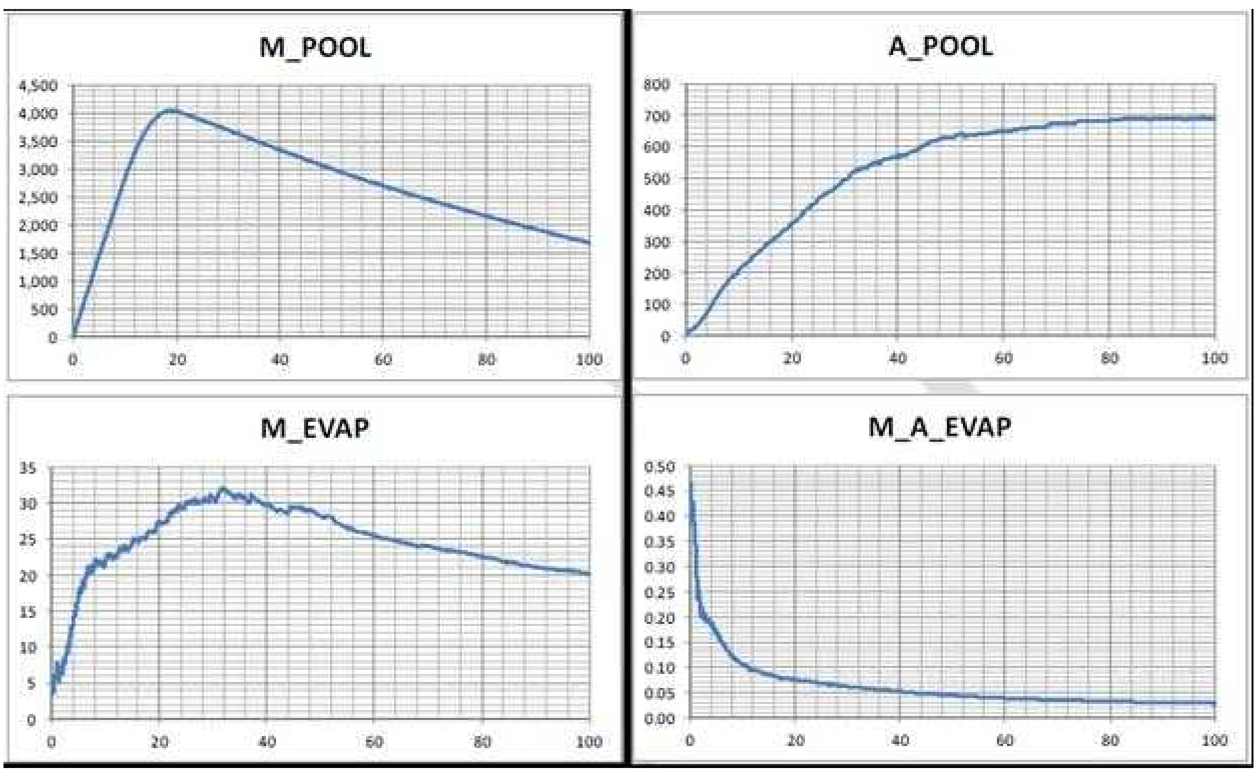
[49] The data is currently available on the National Oceanic and Atmospheric Administration (NOAA) website (http://www.ndbc.noaa.gov/station_page.php?station=44025).
[50] The effect of moisture condensation is not included in the FLACS vapor dispersion simulations

- h is the convective transfer coefficient and a function of the local Reynolds and Prandtl numbers;
- A is the surface of the grid cell;
- T_w is the temperature of the water (typically assumed equal to the ambient temperature, for these types of studies). Note that the temperature of the water is assumed to remain constant – unlike for LNG spills over solid substrates – as the convective flow within the water body continuously replaces the cold water near the surface (due to heat transfer to the LNG pool) with warmer water;
- T_p is the temperature of the pool (typically the boiling point of the spilled liquid).

The FLACS model creates a log file with relevant parameters from the pool model, which can be used to review the growth of the pool, the vaporization rate, etc. throughout a simulation. A graphical example of the data included in pool model log file is shown in Figure 7-3 (note that this example is not from one of the scenarios modeled in this study).

Based on the output from the log file for the pool model, the average LNG vaporization mass flux for the six scenarios was approximately 0.140 kg/s.

Figure 7-3: Sampling Data from FLACS Pool Model Log File (example)



7.5 Hazards Threshold Criteria

7.5.1 Flammable Vapor Dispersion

A flammable vapor cloud can only be ignited if the gas concentration is between the Lower Flammability Limit (LFL) and the Upper Flammability Limit (UFL). For methane, the LFL is 5% (by volume) and the UFL is 15% (by volume). The LFL is used as the hazard threshold for flammable vapor dispersion distances for the Phase I IRA.

7.5.2 Thermal Radiation Heat Flux

Two different thermal radiation levels are considered of interest in the evaluation of risk to the public and property. The thermal radiation thresholds are defined as follows:

- 37.5 kW/m^2: Damage to process equipment and storage tanks for unprotected exposures based on an average 10-minute exposure duration, as well immediate fatalities
- 5 kW/m^2: Permissible level for emergency operations lasting several minutes with appropriate clothing based on an average 10-minute exposed duration and onset of second degree burns based on an average 40 second exposed duration

The results of the pool fire calculations will list the distance to each of these heat fluxes estimated from the center of the pool (i.e., from the spill location).

7.6 LNG Flow from a Tank Breach

If one or more tanks of an LNGRV are breached below the liquid level, LNG will flow through the hole(s). The flow of LNG through a breach is generally modeled as flow through an orifice, driven by the hydrostatic pressure of the LNG above the hole. Assuming atmospheric pressure exists at the top of the breached tank,[51] the volumetric flow through the breach can be calculated as follows:

$$Q(t) = A C_D \sqrt{2\, g\, h(t)}$$

where:

- $Q(t)$ = volumetric flow rate at time t (m^3/s)
- A = cross-sectional area of the breach (m^2)
- C_D = discharge coefficient
- g = acceleration due to gravity (m/s^2)
- $h(t)$ = LNG hydrostatic head above the breach at time t (m)

The discharge coefficient accounts for flow reductions due to the shape of the hole; it typically ranges from approximately 0.3 (when the hole is partially obstructed) to 0.6 (for an unobstructed hole with clean edges). In this study, the spill flow rate calculations were performed using a discharge

[51] This is considered a reasonable assumption since the storage tanks operate a very small gauge pressures and are equipped with vacuum breaks, which open to the atmosphere to prevent collapsing the tank should a vacuum be formed inside.

coefficient equal to 0.6, which maximizes the LNG outflow rate, and therefore represents a conservative assumption.

The hydrostatic head of LNG above the breach varies as a function of time during the spill, decreasing as LNG flows out of the tank(s). The initial hydrostatic head was calculated to be approximately 18.8 m, based on the assumptions that the tanks are approximately 98% full and 70% of the LNG is above the waterline.

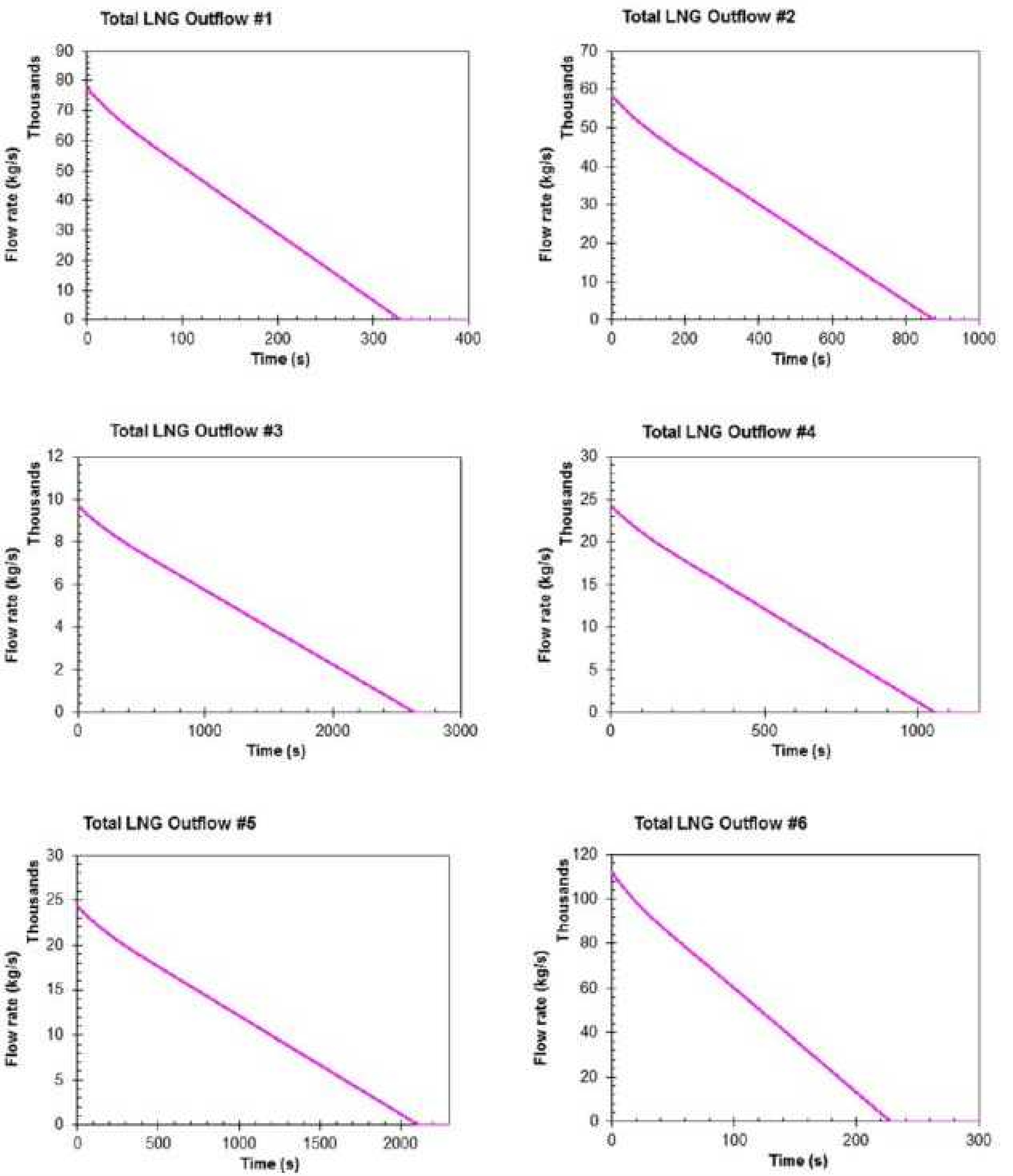
The LNG outflow model used in this study is based on calculations performed by the Federal Energy Regulatory Commission (FERC) staff,[52] modified to account for the non-uniform cross-section of the LNG storage tanks. The orifice flow model gives a time-dependent flow rate, which is the maximum at the onset of flow and decreases monotonically as the LNG inventory is depleted. A summary of the NG flow rates is given in Table 7-2 and graphically in Figure 7-4.

Table 7-2: Modeling Parameters

Scenario No.	Spilled Volume (m^3)	Maximum Flow Rate (kg/s)	Spill Duration (s)
Scenario 1	29,000	77,807	329
Scenario 2	58,000	58,355	878
Scenario 3	29,000	9,726	2,636
Scenario 4	29,000	24,315	1,054
Scenario 5	58,000	24,315	1,054
Scenario 6	29,000	112,334	228

[52] FERC, 2004.

Figure 7-4: LNG Flow Rate for Scenarios 1-6



7.7 LNG Pool Spread over Water

Due to the lighter density of LNG relative to water, LNG spilling onto water will form a pool floating on the surface. The LNG pool will spread onto the water surface due to gravity forces, while some of the LNG will evaporate due to heat transfer from the water. The balance between LNG supply (spill flow from the tank) and removal (evaporation from the pool), as well as the dynamic balance of forces (gravity, inertia and friction), determine the size of the pool as a function of time. The LNG pool evaporation flux depends on the temperature difference between water and LNG, which is assumed to remain constant over time due to convective motion within the water column, through a heat transfer coefficient which depends on both the physical properties of the fluids as well as the local relative motion between the spreading pool and the underlying water. Therefore, the evaporation rate varies in both time and space in a complex manner, yielding different results from the simpler, mass balance based calculations performed for the thermal radiation hazard analysis.

As discussed in Section 7.2, the behavior of the LNG pool on the water surface (spreading and vaporization) is calculated within FLACS, thanks to the shallow water-based pool model. A summary of the LNG pool growth for the six scenarios included in this study is shown in Figure 7-5. Note that the FLACS pool model is not constrained to assuming a circular (or semi-circular) pool shape; in fact, as shown in Figure 7-6, the pool spreads alongside the vessel and then wraps around the bow. Therefore, the pool "diameters" listed in Table 7-3 represent the diameter of an equivalent circular pool with the same area as the irregularly-shaped pool calculated by FLACS and shown in Figure 7-6.

Table 7-3: LNG Pool Spread Over Water

Scenario No.	Spilled Volume (m^3)	Maximum Pool Diameter (meters) (measured from the center of the pool)
Scenario 1	29,000	533
Scenario 2	58,000	556
Scenario 3	29,000	268
Scenario 4	29,000	382
Scenario 5	58,000	410
Scenario 6	29,000	541

Figure 7-5: LNG Pool Size vs. Time for Scenarios 1-6

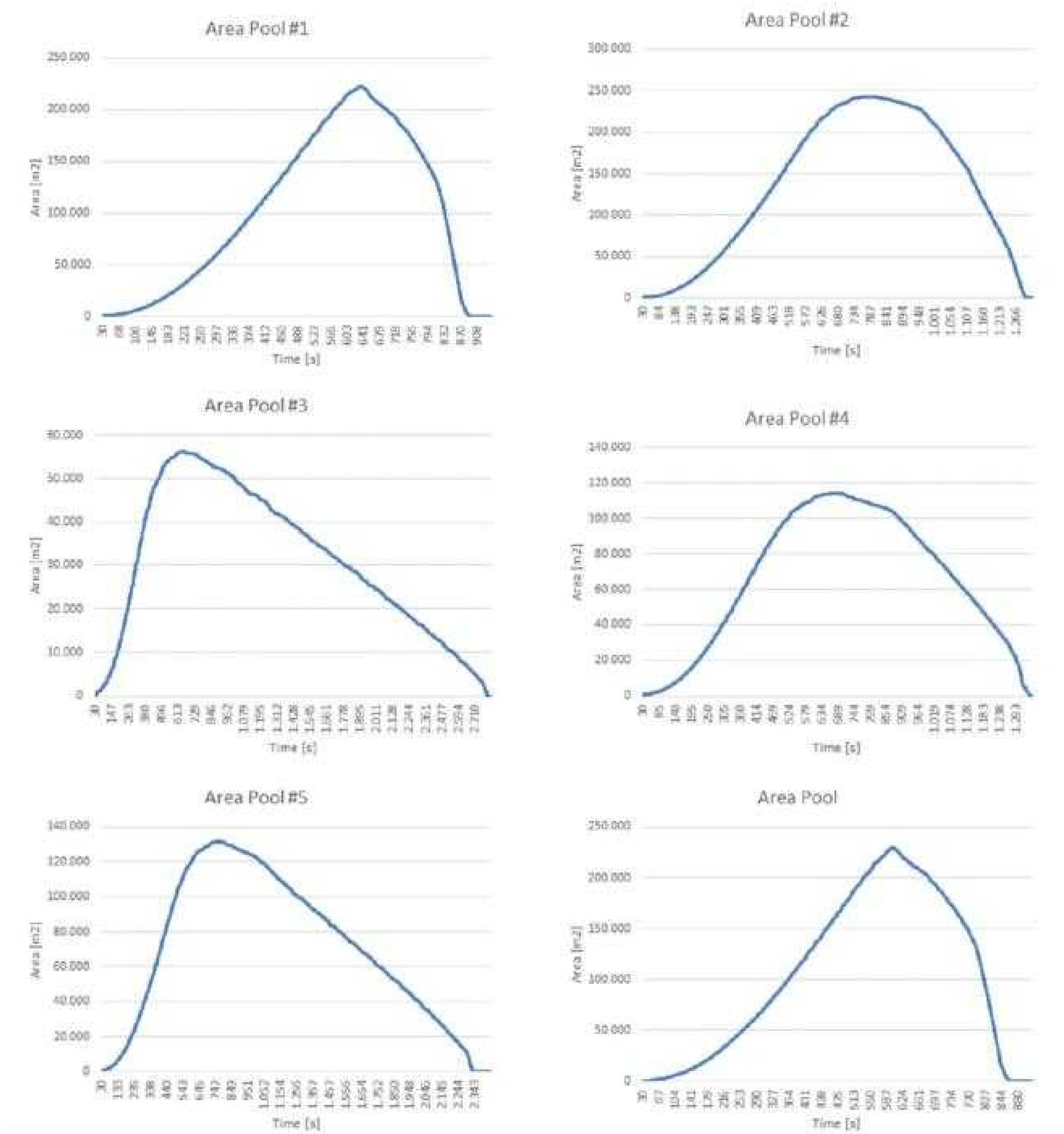
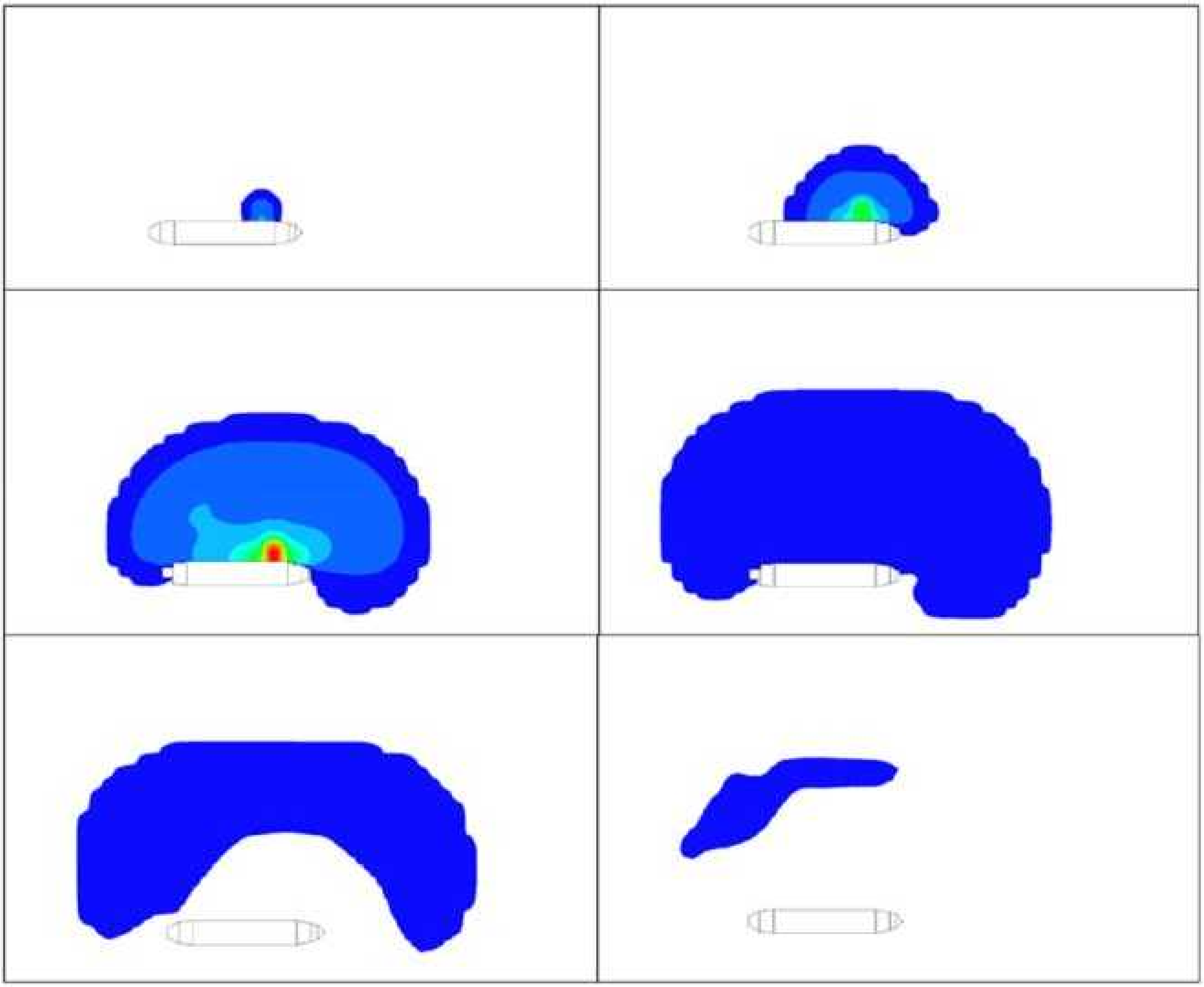


Figure 7-6: Snapshot of the LNG Pool Growth at Different Times for Scenarios 1



7.8 LNG Pool Fire Modeling

An LNG spill scenario can result in a pool fire when an LNG pool is formed onto the water surface and the vapors emanating from the pool are ignited close to the pool. The pool fire is fueled by the LNG that evaporates from the pool, as a result of heat transfer from the water underneath and the radiation from the fire above. The size of the LNG pool, and therefore the size of the pool fire, change with time as the pool spreads and recedes (see previous section). Therefore, the thermal radiation heat flux to a stationary target is a function of time, increasing when the pool expands towards the target and decreasing when the pool recedes towards the vessel. A conservative estimate of the radiation heat flux to a stationary target can be obtained by assuming the pool to be at equilibrium relative to the average spill rate – that is, the pool size is assumed to be such that the vaporization rate (under burning conditions) is equal to the mass added to the pool by the LNG spill.

With the exception of the LNGRV, there are no other structures or geometric obstacles expected to be in proximity of the proposed DWP that could affect the growth of a pool fire or shield potential targets from the fire's radiation. Therefore, CFD models of the pool fire are not deemed necessary and simpler models can be used to calculate the thermal radiation hazard distances.

A very common model for these scenarios is the solid flame model[53]: the fire is represented as a cylinder, whose base is equal to the area of the pool of fuel and whose height is determined from semi-empirical correlations. The radiation from the cylinder to a target depends on the emissive power of the fire surface, the transmissivity of the atmosphere, and the position of the target relative to the fire (the "view factor"). The hazard distances for this study were calculated according to the recommendations published by Sandia[54] in 2011 following the analysis of their large-scale LNG pool fire tests, as summarized in Table 7-4.

Table 7-4: LNG Pool Fire Modeling Parameters (other than ambient conditions)

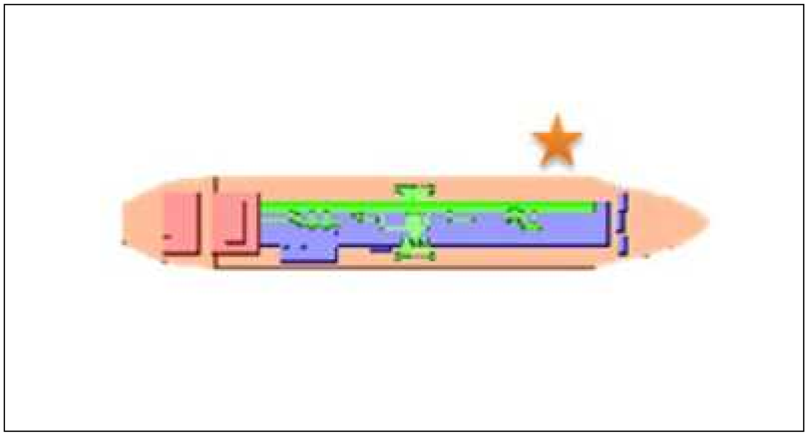
Parameter	Value
Discharge Coefficient	0.6
Burning Rate	3.5×10^{-4} m/s
Surface Emissive Power	286 kW/m^2
Atmospheric Transmissivity	Wayne[55] formula
Flame Height Correlation	SNL correlation
Flame Tilt Correlation	AGA[56] Model

7.9 Flammable Vapor Dispersion Results

The dispersion of LNG vapors from a spill on water were calculated using the FLACS CFD model and the parameters described earlier. A simple model of the LNG carrier is included in the FLACS 3D model for these simulations. According to the proposed plans, the unloading vessels will be moored to the buoy and therefore will be able to weathervane while at berth. Therefore, in the simulations the vessel is assumed to be aligned with the wind direction. The tank breach is assumed to occur at the waterline, at midship on the port side of the LNG carrier, as shown in Figure 7-7.

[53] Beyler, 2002.
[54] A. Luketa, Recommendations on the Prediction of Thermal Hazard Distances from Large Liquefied Natural Gas Pool Fires on Water for Solid Flame Models, SAND2011-9415 (2011).
[55] Wayne, D.F. "An Economical Forum for Calculating Atmospheric Infrared Transmissivities." *J. Loss Prev. Process Ind.*, 1991: 85-92
[56] "LNG Safety Research Program," *Report IS 3-1,* American Gas Association (1974).

Figure 7-7: LNG Pool Location (port side of the LNGRV)



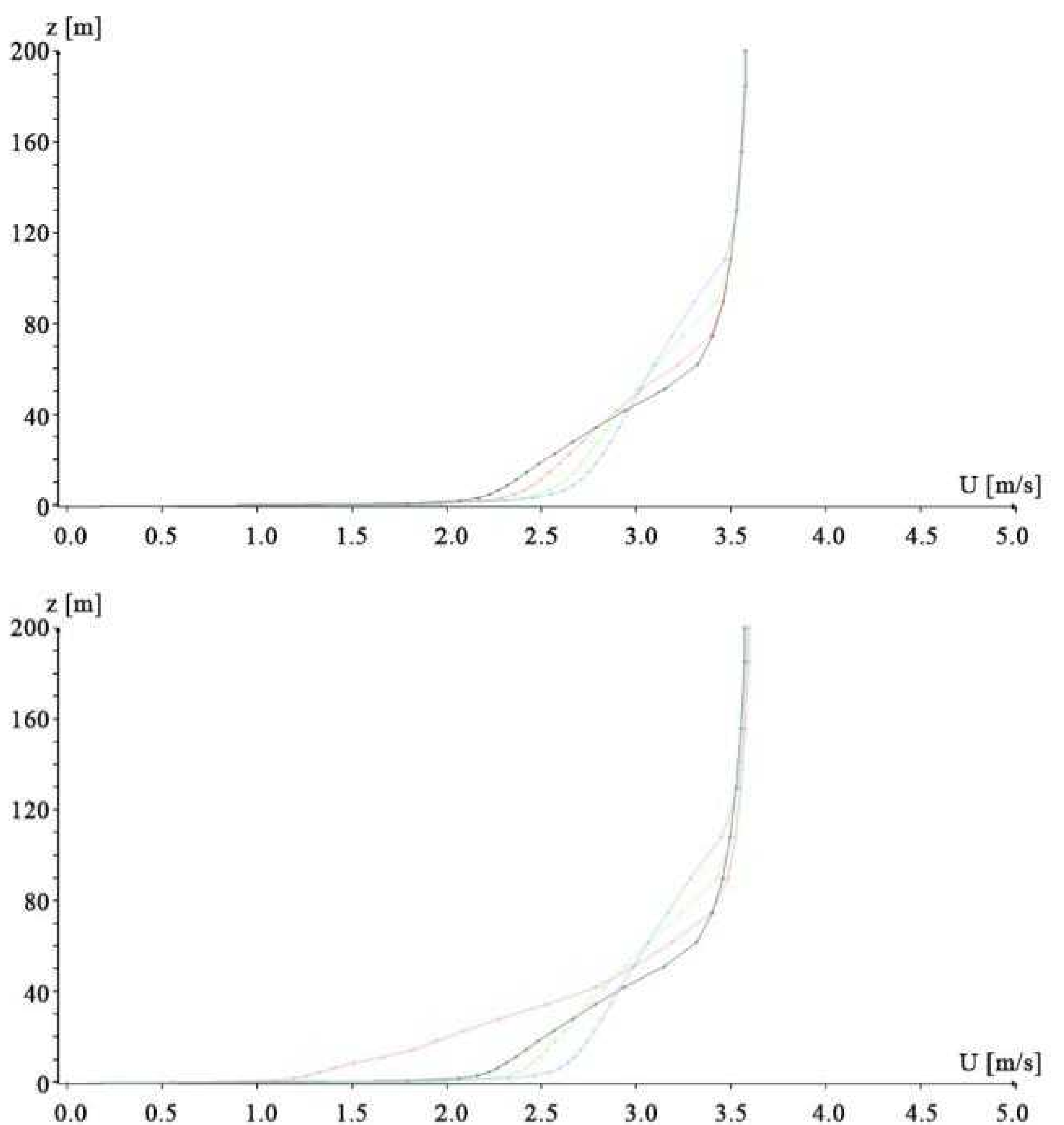
Given the single-block, Cartesian mesh adopted in FLACS, two different sets of computational domains were used in the simulations:

1. A small domain focused on resolving the LNG pool spreading and vaporization was used to calculate the maximum area of the pool. The simulation domain extends from 500 m upwind of the spill to 800 m downwind, spanning 700 m on the port side of the ship (the side of the spill) and 500 m on the starboard side of the ship. The ceiling for the simulation domain is set to 50 m. The horizontal grid resolution ranges from 5 m in the area of the spill to 10 m downwind; the vertical resolution is 1 m near water level and stretched upwards.
2. A domain focused on resolving the LNG pool spreading and vaporization was used, as well as the dispersion of the LNG vapor cloud. The simulation domain extends from 2 km upwind of the spill to 5 km downwind, spanning 3 km crosswind on both sides of the ship. The ceiling for the simulation domain is set to 200 m. The horizontal grid resolution ranges from 2 m in the area of the spill to 50 m downwind; the vertical resolution is 1 m near water level and stretched upwards.

The computational grid dimensions were selected based on the FLACS validation work previously performed by GexCon for LNG vapor dispersion, taking also into account the available computational resources and project schedule.

An atmospheric boundary layer wind profile is imposed on the upwind, cross-wind and top boundaries of the domain. The downwind boundary is left open. The velocity and turbulence profiles are determined using the specified velocity ambient conditions (see Table 7-1) and the Monin-Obukhov equations, which are built into the FLACS model. Figure 7-8 shows the wind velocity profile at different locations along the simulation domain, prior to the LNG spill. The horizontal axis represents the wind velocity (wind blows along the X direction in the simulation domain), and the vertical axis represents the elevation above the water surface. The off-center locations (2 km crosswind from the pool mid-plane), show that the velocity profiles remain consistent with the imposed boundary conditions throughout the domain (there is no effect from the tanker at those locations). The plots along the pool mid-plane show the effect of the LNG tanker on the atmospheric profile (wind speed is approximately zero (0) up to the elevation of the tanker deck).

Figure 7-8: Vertical Profile of Wind Velocity at Different Downwind Locations for Scenario 1 (top: along pool centerline; bottom: 2 km off-center).



7.9.1 Scenario 1 – Vapor Cloud Dispersion Results

Snapshots from the simulation of the flammable vapor cloud dispersion for Scenario 1 are shown in Figure 7-9 through Figure 7-11. The plots show the LNG pool on the left, color-coded according to the thickness of the liquid, and the footprint of the vapor cloud at concentrations equal to or greater than LFL (5% methane by volume), color-coded according to the gas concentration at water level. The sequence of images shows the initial growth of the pool and of the flammable cloud, followed by the downwind drift of the cloud and its progressive dissipation once the LNG pool is depleted.

The maximum distance reached by the flammable vapors in Scenario 1 is approximately 2,800 m from the location of the spill. The maximum distance to LFL is reached approximately 22 minutes after the tank is first breached.

Figure 7-9: Snapshot of the LNG Vapor Cloud for Scenario 1 (at approximately 11 minutes after tank breach)

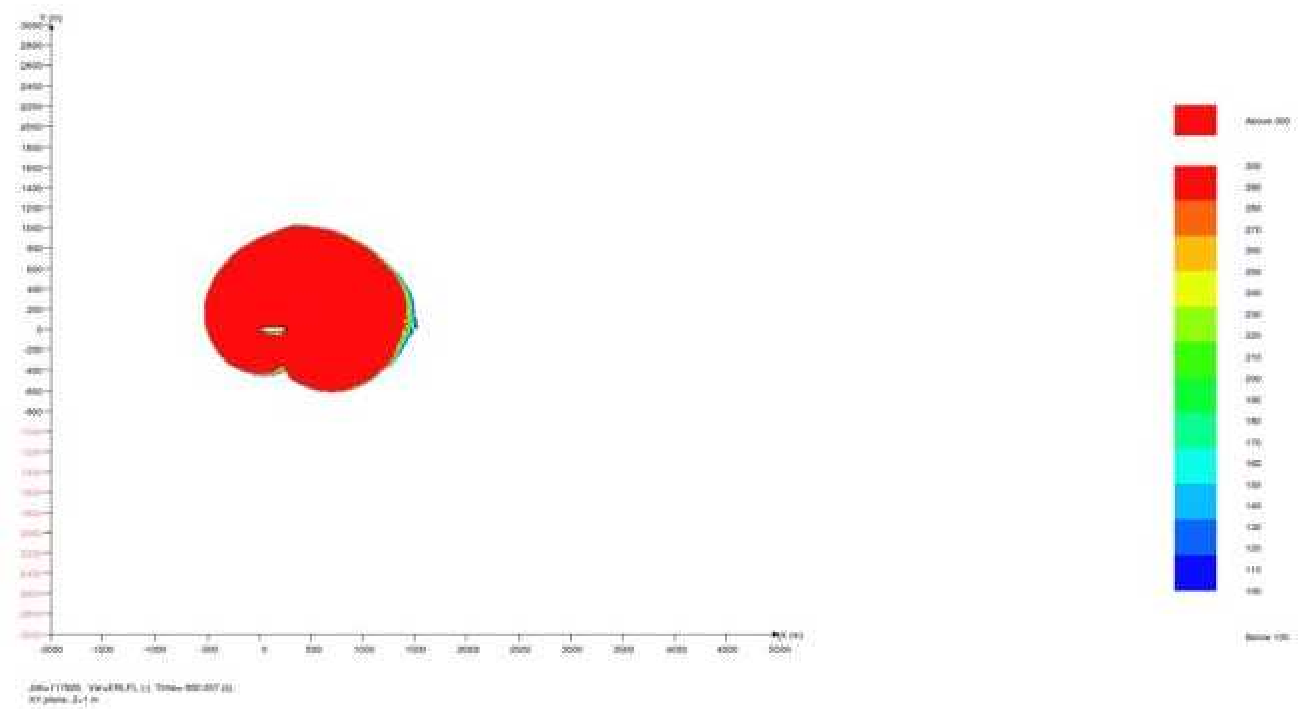


Figure 7-10: Snapshot of the LNG Vapor Cloud for Scenario 1 (at approximately 22 minutes after tank breach)

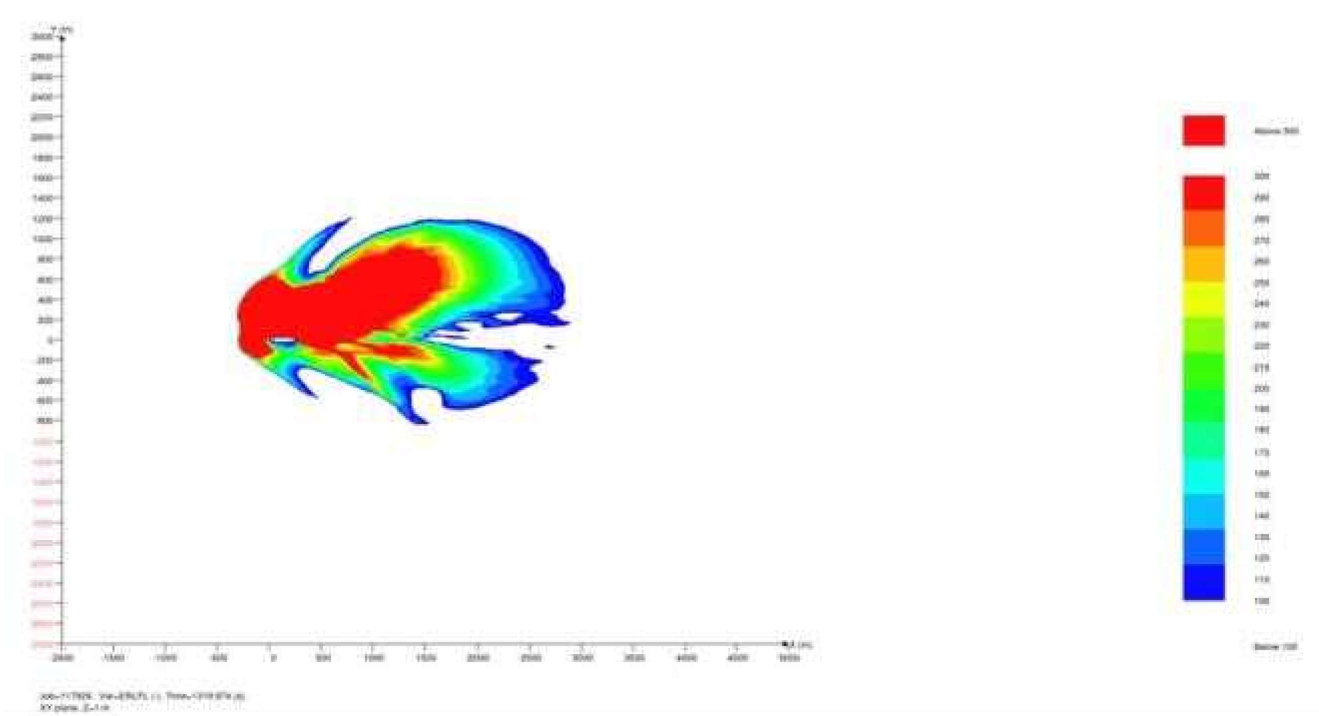
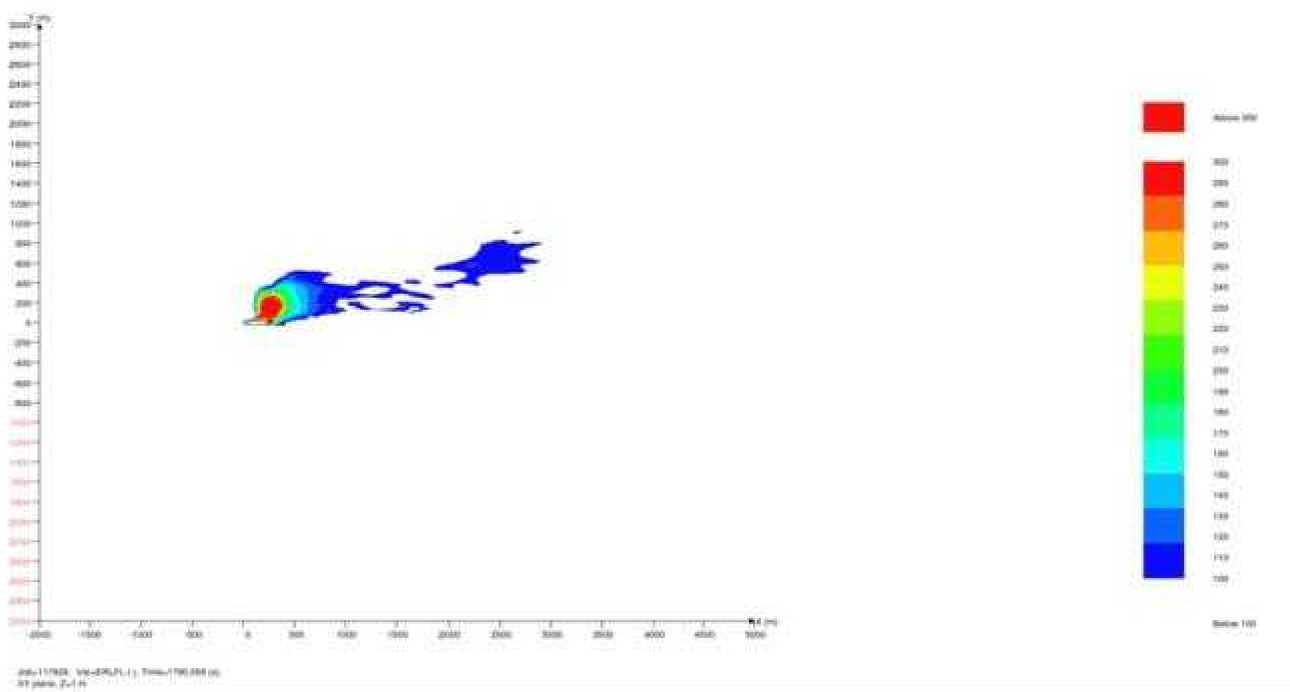


Figure 7-11: Snapshot of the LNG Vapor Cloud for Scenario 1 (at approximately 30 minutes after tank breach)



7.9.2 Scenario 2 – Vapor Cloud Dispersion Results

Snapshots from the simulation of the flammable vapor cloud dispersion for Scenario 2 are shown in Figure 7-12 through Figure 7-14. The plots show the LNG pool on the left, color-coded according to the thickness of the liquid, and the footprint of the vapor cloud at concentrations equal to or greater than LFL (5% methane by volume), color-coded according to the gas concentration at water level. The sequence of images shows the initial growth of the pool and of the flammable cloud, followed by the downwind drift of the cloud and its progressive dissipation once the LNG pool is depleted.

The maximum distance reached by the flammable vapors in Scenario 2 is approximately 3,550 m from the location of the spill. The maximum distance to LFL is reached approximately 27 minutes after the tank is first breached.

Figure 7-12: Snapshot of the LNG Vapor Cloud for Scenario 2 (at approximately 13.5 minutes after tank breach)

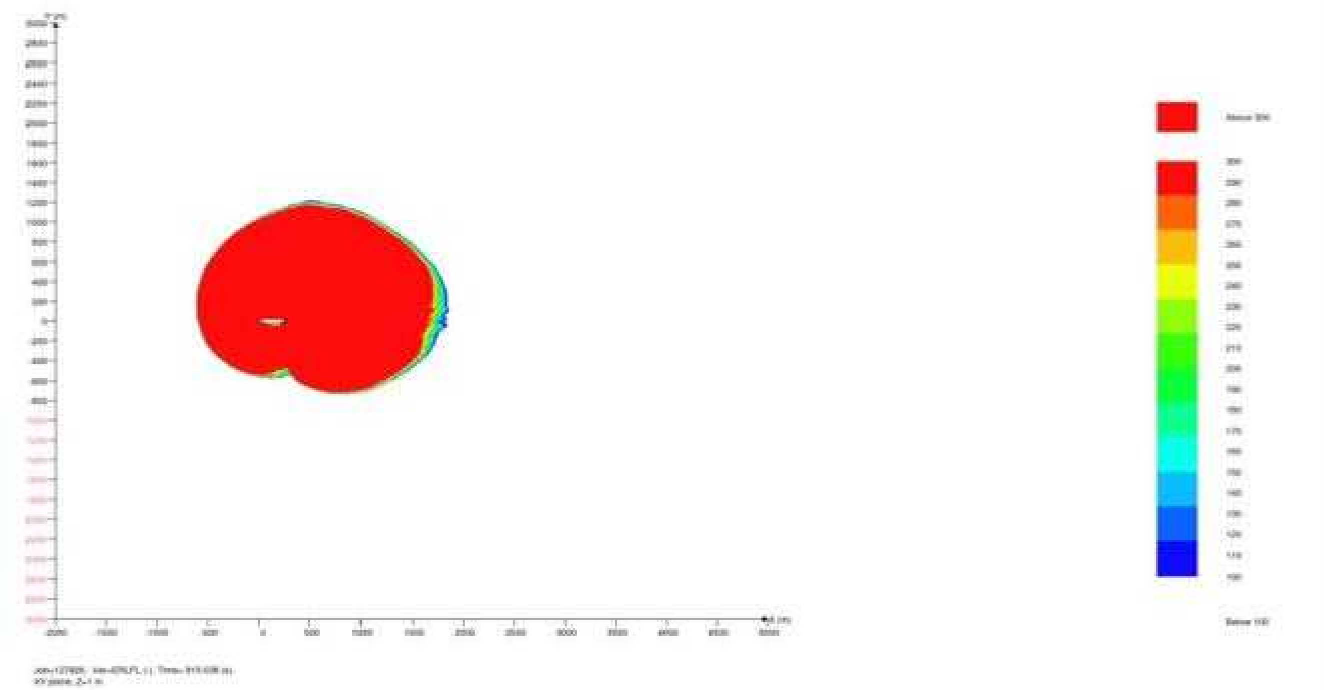


Figure 7-13: Snapshot of the LNG Vapor Cloud for Scenario 2 (at approximately 27 minutes after tank breach)

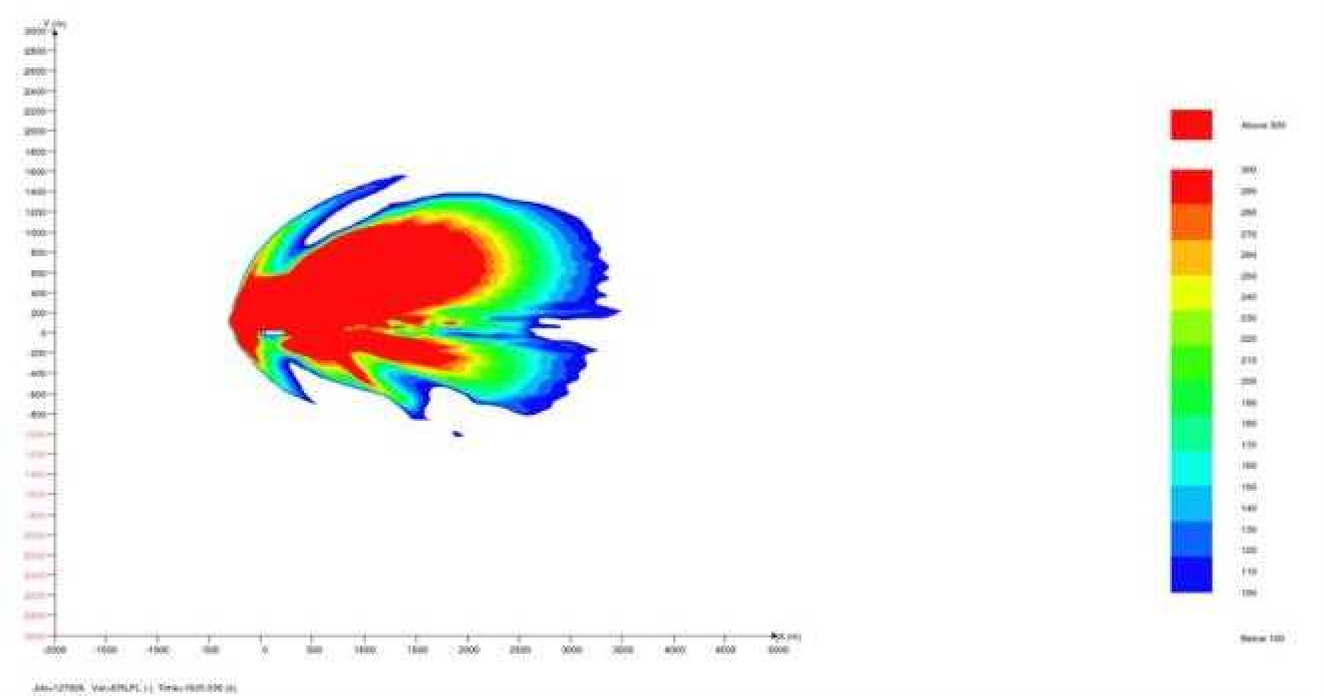
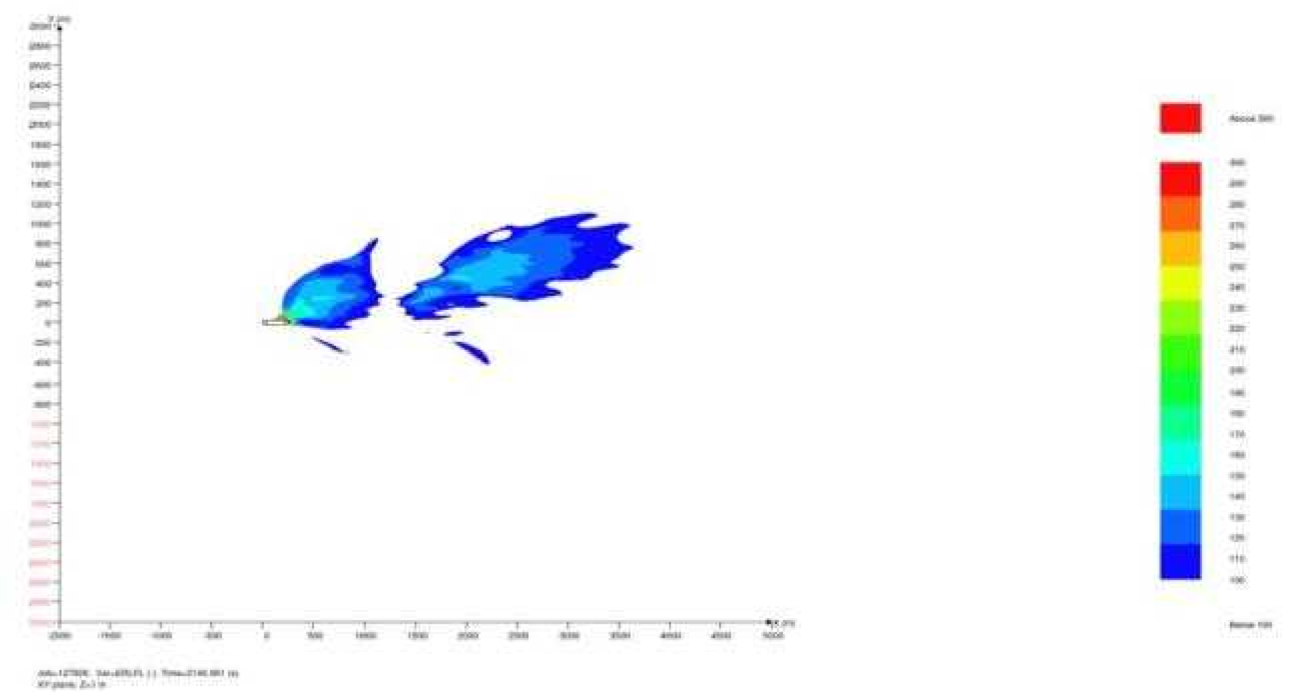


Figure 7-14: Snapshot of the LNG Vapor Cloud for Scenario 2 (at approximately 35 minutes after tank breach)



7.9.3 Scenario 3 – Vapor Cloud Dispersion Results

Snapshots from the simulation of the flammable vapor cloud dispersion for Scenario 3 are shown in Figure 7-15 through Figure 7-17. The plots show the LNG pool on the left, color-coded according to the thickness of the liquid, and the footprint of the vapor cloud at concentrations equal to or greater than LFL (5% methane by volume), color-coded according to the gas concentration at water level. The sequence of images shows the initial growth of the pool and of the flammable cloud, followed by the downwind drift of the cloud and its progressive dissipation once the LNG pool is depleted.

The maximum distance reached by the flammable vapors in Scenario 3 is approximately 2,350 m from the location of the spill. The maximum distance to LFL is reached approximately 27 minutes after the tank is first breached.

Figure 7-15: Snapshot of the LNG Vapor Cloud for Scenario 3 (at approximately 13.5 minutes after tank breach)

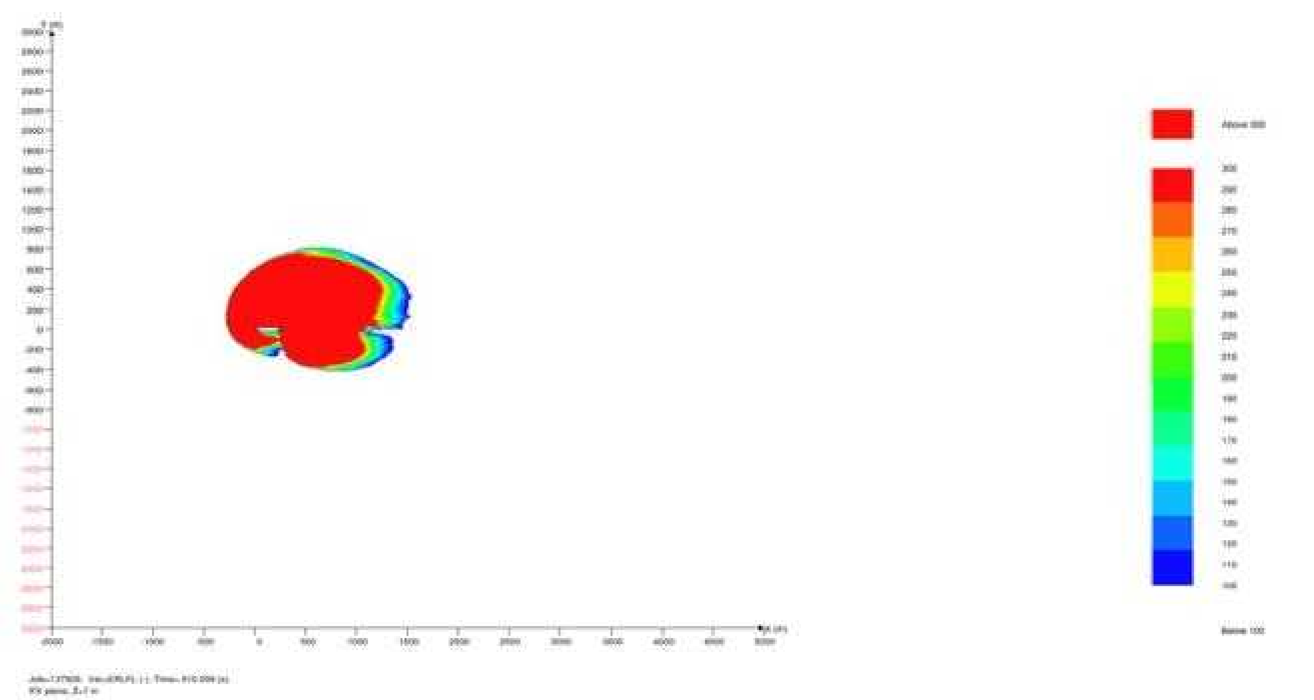


Figure 7-16: Snapshot of the LNG Vapor Cloud for Scenario 3 (at approximately 27 minutes after tank breach)

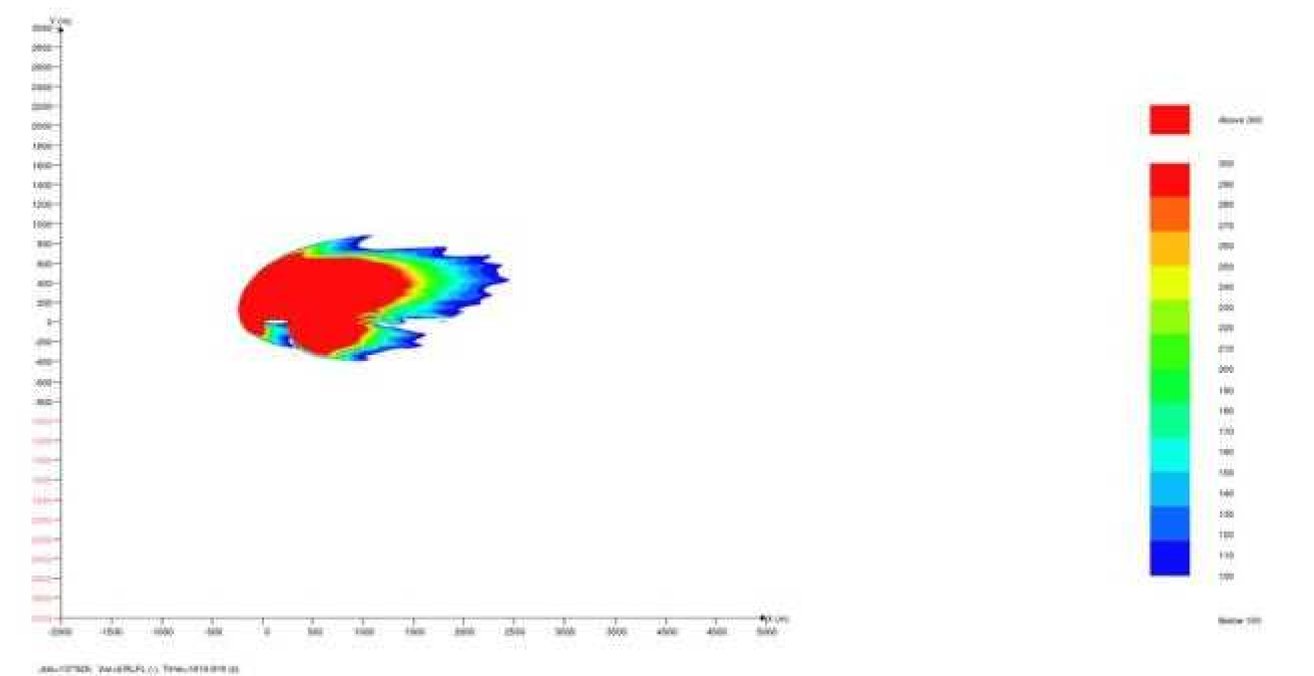
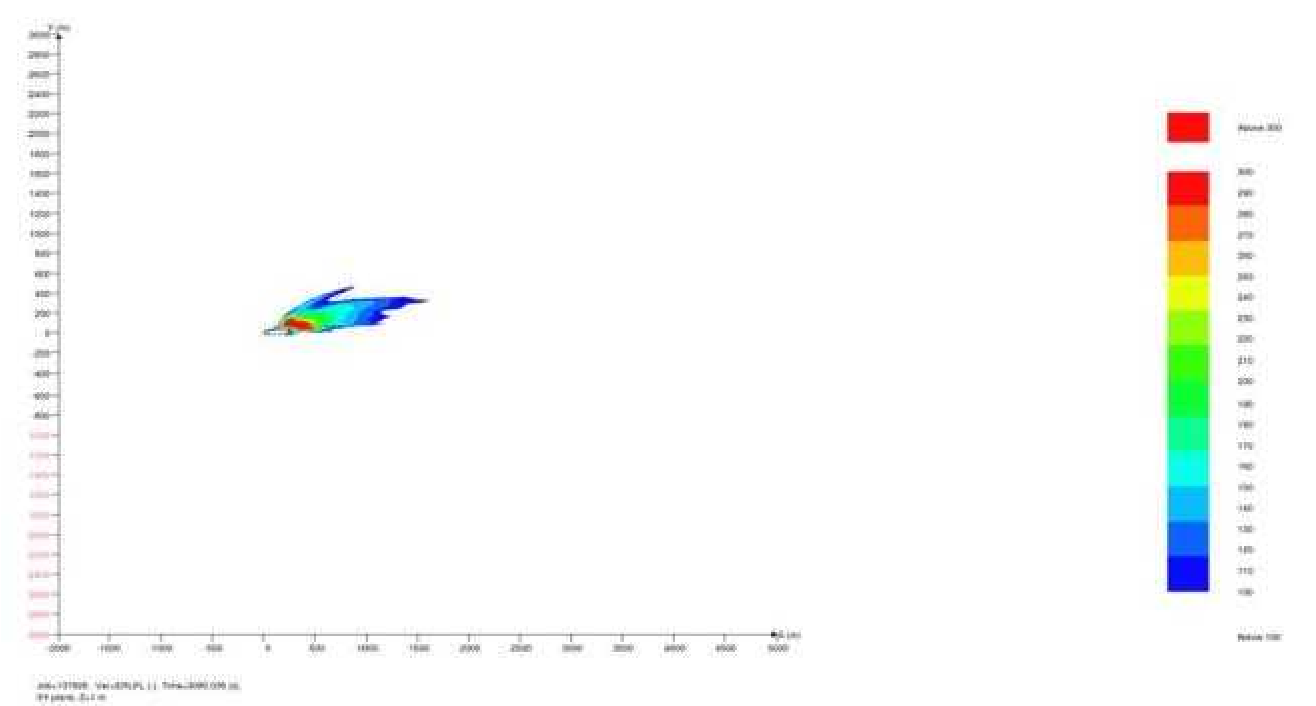


Figure 7-17: Snapshot of the LNG Vapor Cloud for Scenario 3 (at approximately 51 minutes after tank breach)



7.9.4 Scenario 4 – Vapor Cloud Dispersion Results

Snapshots from the simulation of the flammable vapor cloud dispersion for Scenario 4 are shown in Figure 7-18 through Figure 7-20. The plots show the LNG pool on the left, color-coded according to the thickness of the liquid, and the footprint of the vapor cloud at concentrations equal to or greater than LFL (5% methane by volume), color-coded according to the gas concentration at water level. The sequence of images shows the initial growth of the pool and of the flammable cloud, followed by the downwind drift of the cloud and its progressive dissipation once the LNG pool is depleted.

The maximum distance reached by the flammable vapors in Scenario 4 is approximately 2,800 m from the location of the spill. The maximum distance to LFL is reached approximately 29 minutes after the tank is first breached.

Figure 7-18: Snapshot of the LNG Vapor Cloud for Scenario 4 (at approximately 14.5 minutes after tank breach)

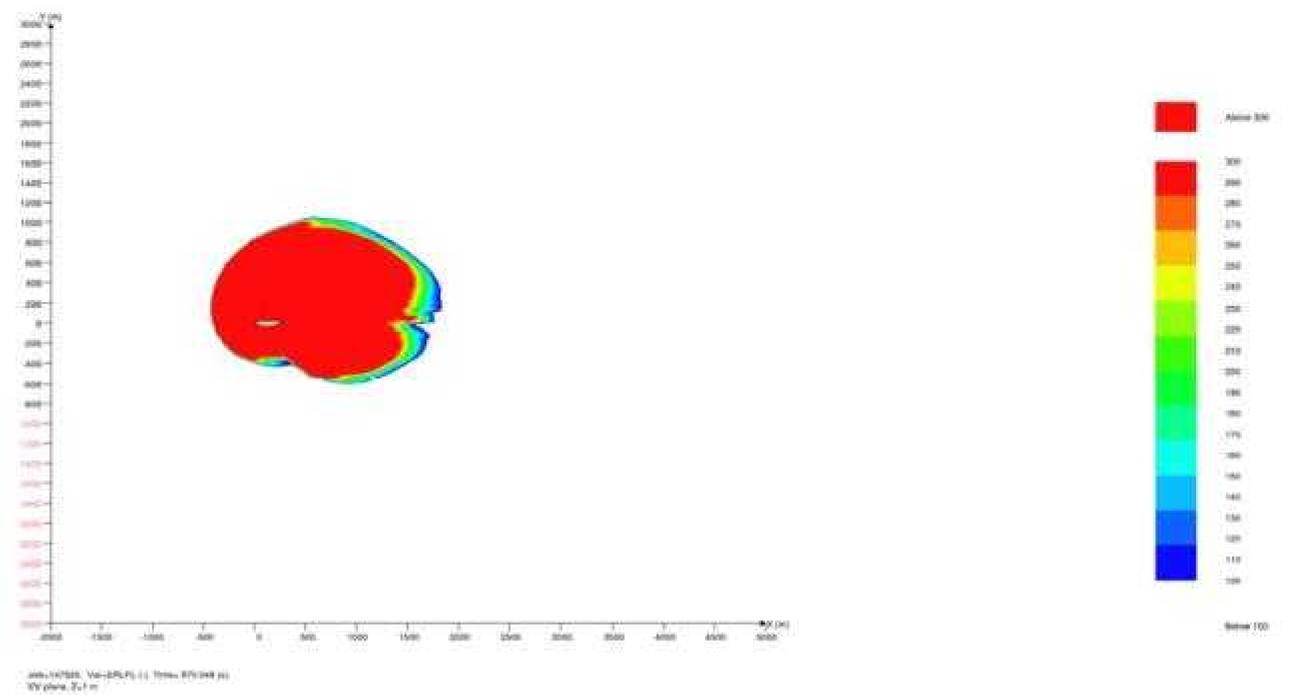


Figure 7-19: Snapshot of the LNG Vapor Cloud for Scenario 4 (at approximately 29 minutes after tank breach)

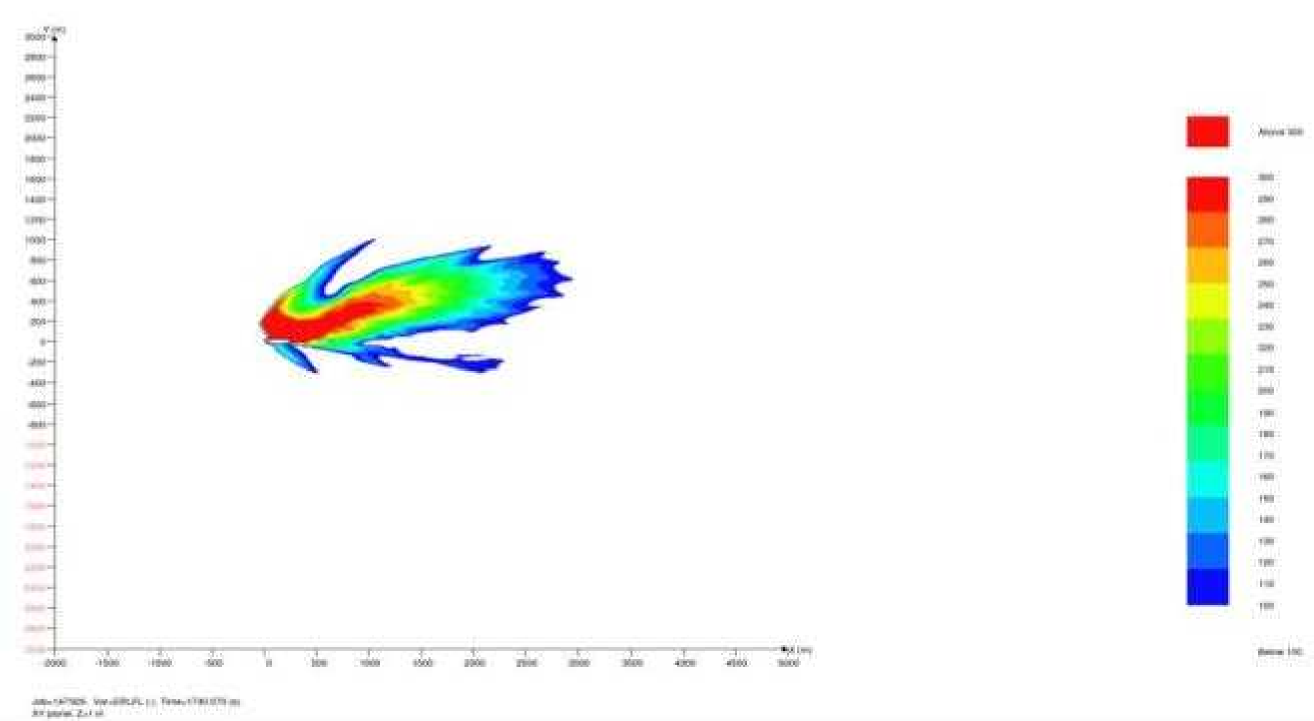
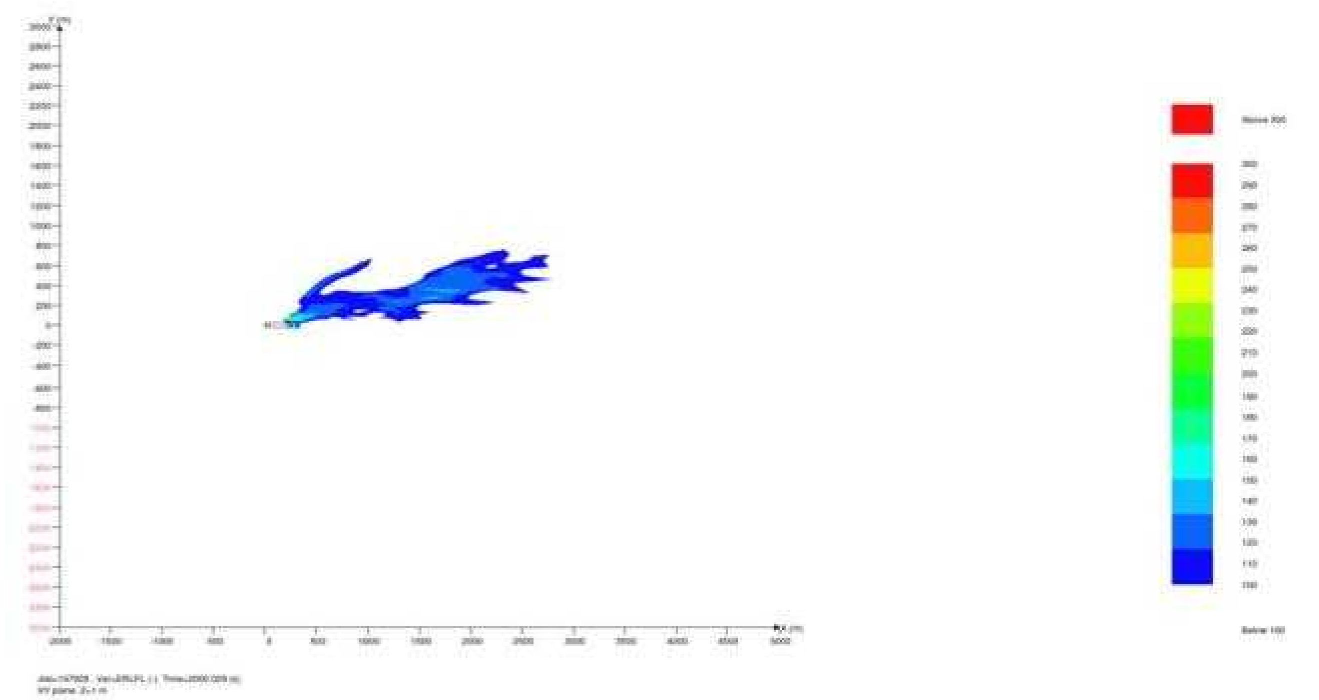


Figure 7-20: Snapshot of the LNG Vapor Cloud for Scenario 4 (at approximately 33 minutes after tank breach)



7.9.5 Scenario 5 – Vapor Cloud Dispersion Results

Snapshots from the simulation of the flammable vapor cloud dispersion for Scenario 5 are shown in Figure 7-21 through Figure 7-23. The plots show the LNG pool on the left, color-coded according to the thickness of the liquid, and the footprint of the vapor cloud at concentrations equal to or greater than LFL (5% methane by volume), color-coded according to the gas concentration at water level. The sequence of images shows the initial growth of the pool and of the flammable cloud, followed by the downwind drift of the cloud and its progressive dissipation once the LNG pool is depleted.

The maximum distance reached by the flammable vapors in Scenario 5 is approximately 3,150 m from the location of the spill. The maximum distance to LFL is reached approximately 33 minutes after the tank is first breached.

Figure 7-21: Snapshot of the LNG Vapor Cloud for Scenario 5 (at approximately 16.5 minutes after tank breach)

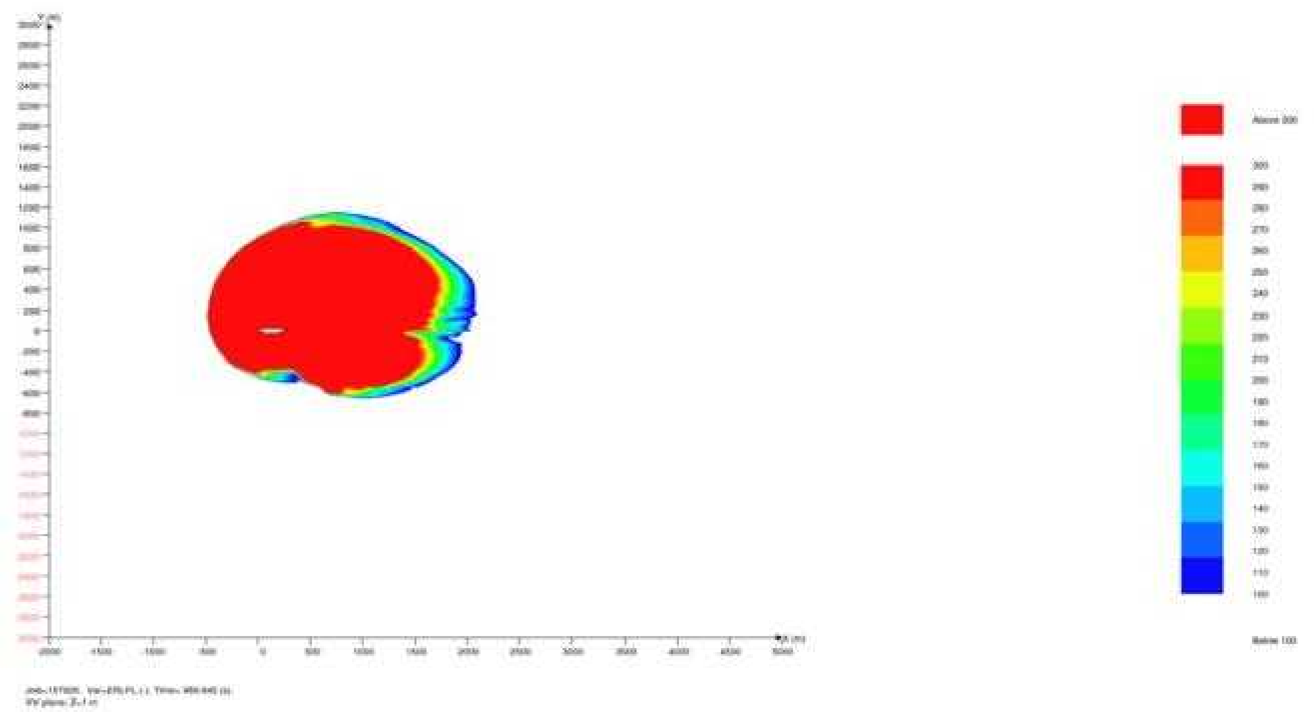


Figure 7-22: Snapshot of the LNG Vapor Cloud for Scenario 5 (at approximately 33 minutes after tank breach)

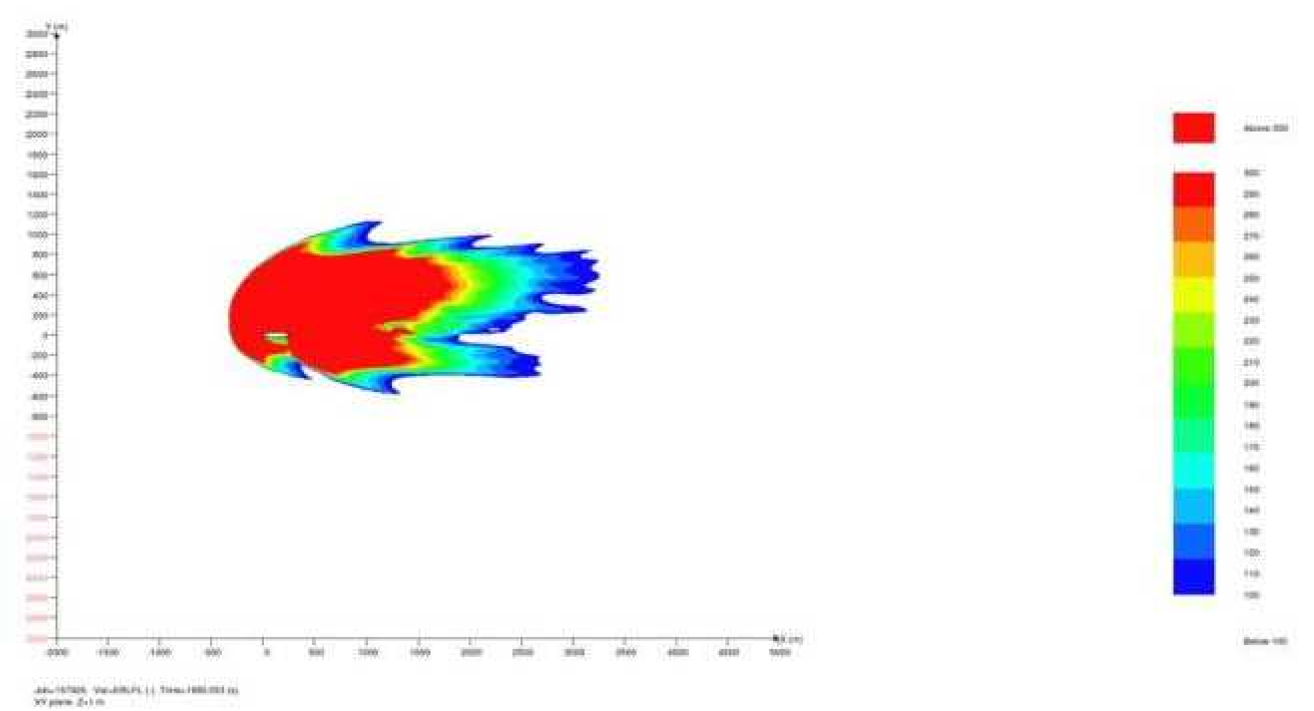
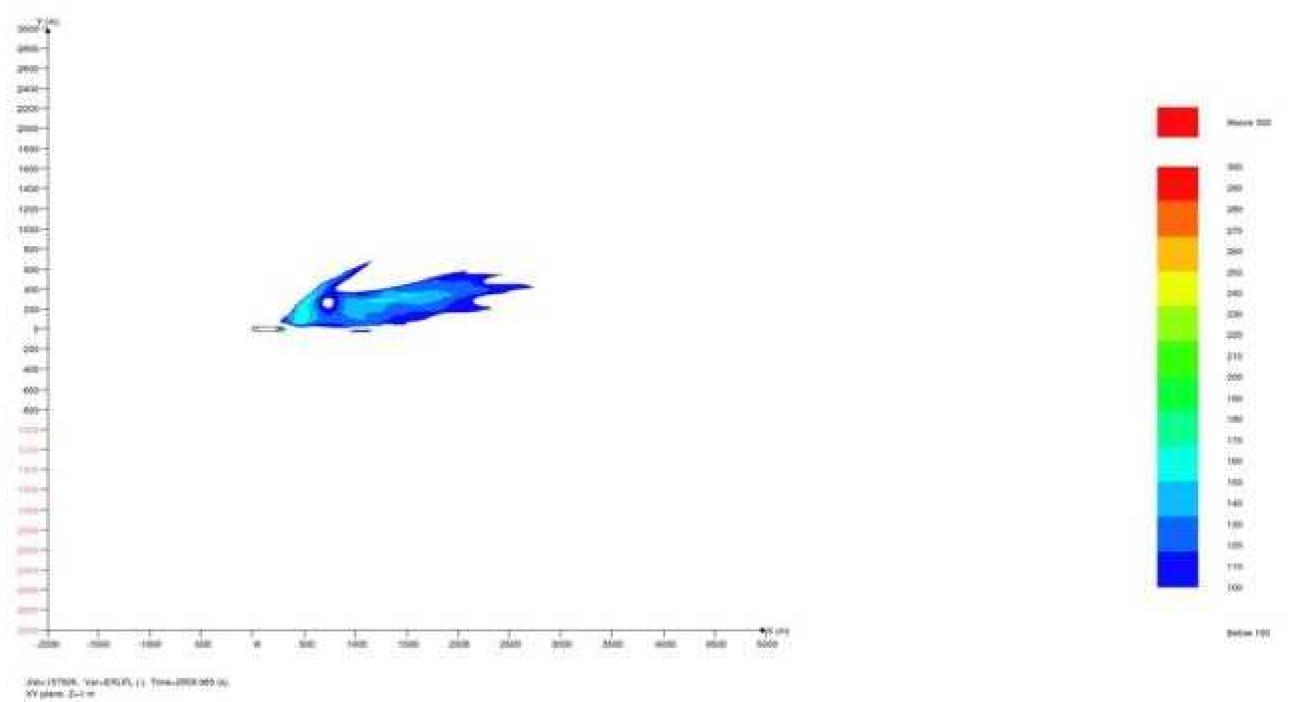


Figure 7-23: Snapshot of the LNG Vapor Cloud for Scenario 5 (at approximately 48 minutes after tank breach)



7.9.6 Scenario 6 – Vapor Cloud Dispersion Results

Snapshots from the simulation of the flammable vapor cloud dispersion for Scenario 6 are shown in Figure 7-24 through Figure 7-26. The plots show the LNG pool on the left, color-coded according to the thickness of the liquid, and the footprint of the vapor cloud at concentrations equal to or greater than LFL (5% methane by volume), color-coded according to the gas concentration at water level. The sequence of images shows the initial growth of the pool and of the flammable cloud, followed by the downwind drift of the cloud and its progressive dissipation once the LNG pool is depleted.

The maximum distance reached by the flammable vapors in Scenario 6 is approximately 2,750 m from the location of the spill. The maximum distance to LFL is reached approximately 22 minutes after the tank is first breached.

Figure 7-24: Snapshot of the LNG Vapor Cloud for Scenario 6 (at approximately 11 minutes after tank breach)

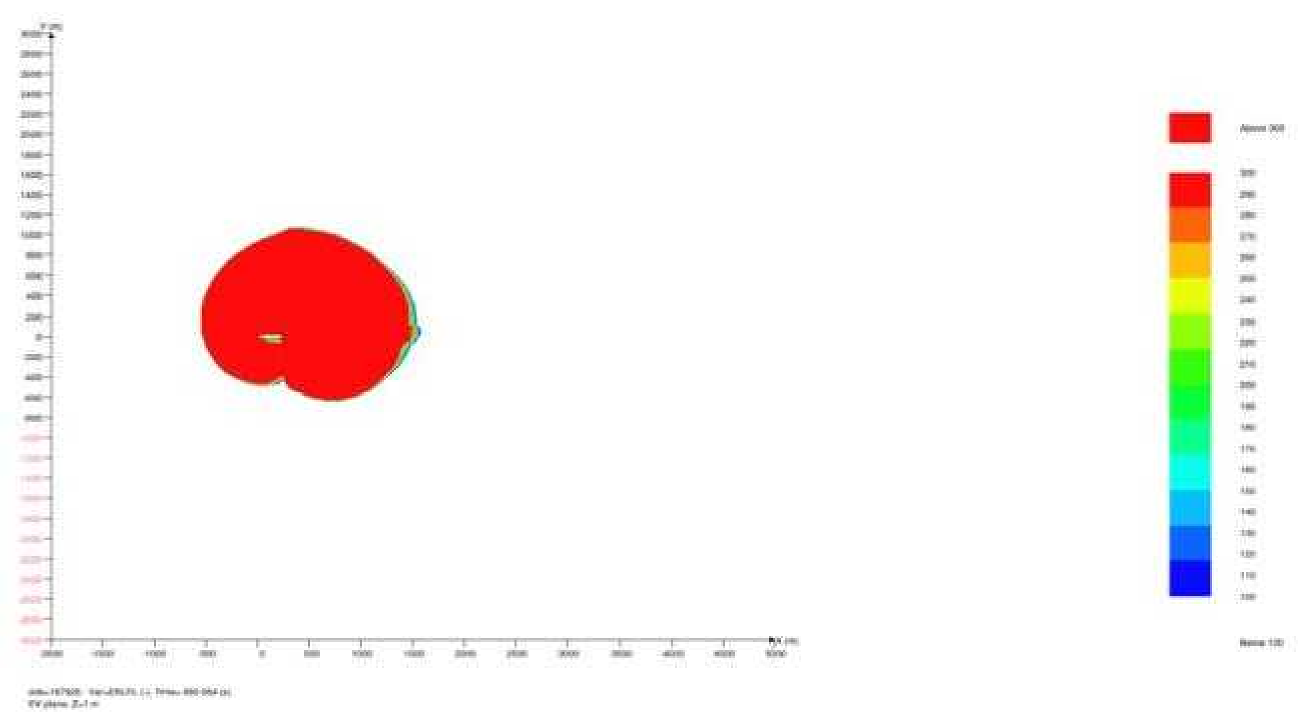


Figure 7-25: Snapshot of the LNG Vapor Cloud for Scenario 6 (at approximately 22 minutes after tank breach)

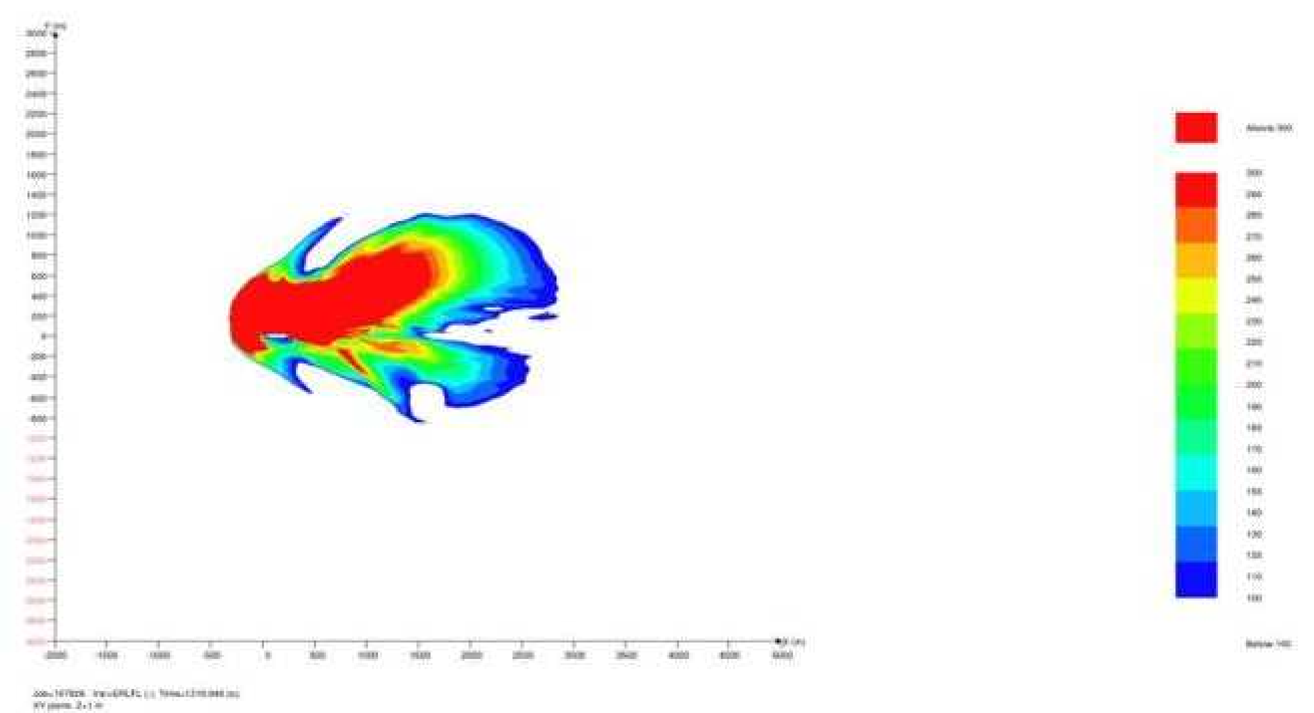
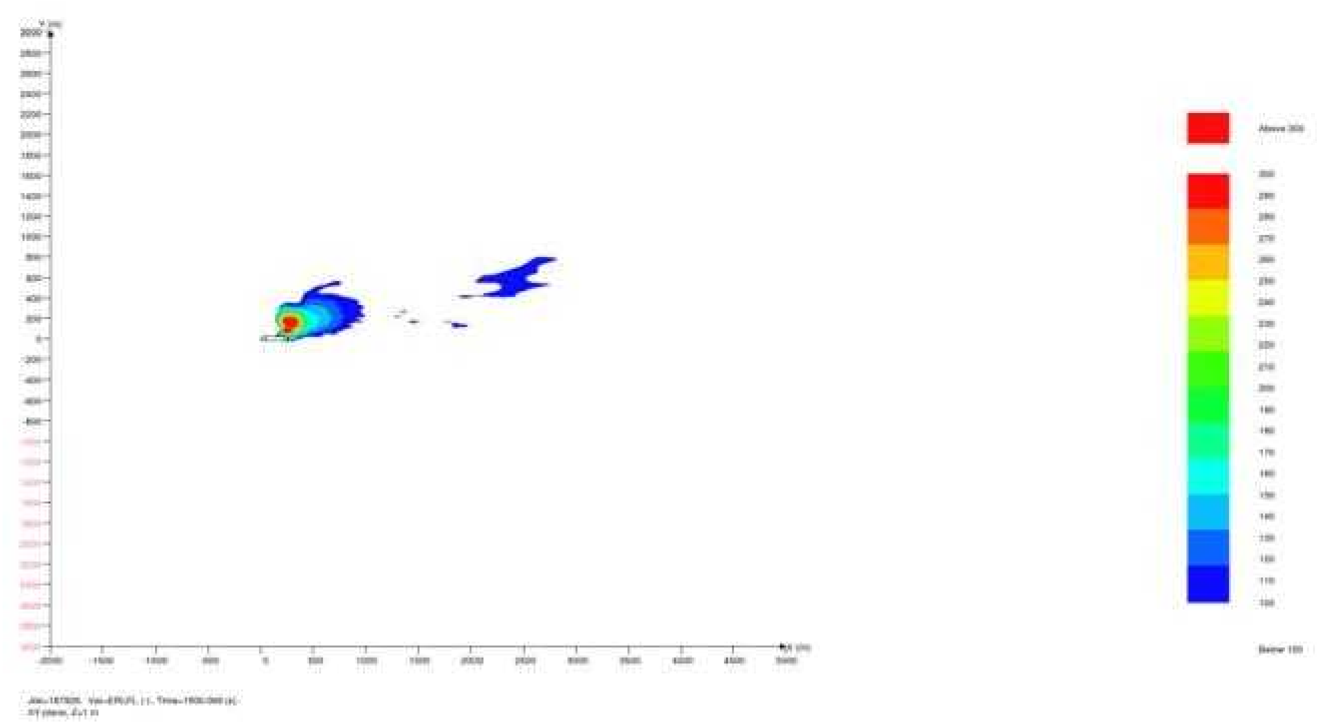


Figure 7-26: Snapshot of the LNG Vapor Cloud for Scenario 6 (at approximately 30 minutes after tank breach)



7.10 Thermal Radiation from LNG Pool Fire Results

The hazard distances to the selected heat flux levels (37.5, 25 and 5 kW/m2) calculated using the equilibrium pool diameters as specified in Section 7.8 are listed in Table 7-5. The thermal radiation hazard distances are measured from the center of the LNG pool.

Table 7-5: Radiation Heat Flux Results for Scenarios 1-6

Scenario No.	Diameter (m)	Distance (m) to 37.5 kW/m2	Distance (m) to 5 kW/m^2
1	579	970	2,270
2	709	1,110	2,640
3	205	460	1,020
4	324	650	1,460
5	458	820	1,900
6	696	1,090	2,600

8.0 IRA Results and Conclusions

The following section details the results of the consequence modeling and collision frequencies. Consequence results are depicted graphically on nautical charts.

8.1 Consequence Modeling Results

Thermal radiation hazard calculations from both pool fires and flammable vapor dispersion modeling to the lower flammability limit (LFL) were performed for the following LNG regasification vessel (LNGRV) release scenarios for the Port Ambrose deepwater (DWP) project:

- Scenario 1: Intentional attack leading to a 16 m^2 breach in a single LNGRV tank
- Scenario 2: Intentional attack leading to a 12 m^2 breach in two (2) LNGRV tanks
- Scenario 3: Hijacking attack leading to a 2 m^2 breach in a single LNGRV tank
- Scenario 4: Hijacking attack leading to a 5 m^2 breach in a single LNGRV tank
- Scenario 5: Hijacking attack leading to a 2 m^2 breach in two (2) LNGRV tanks
- Scenario 6: Vessel collision/allision leading to a 23.1 m^2 breach in a single LNGRV tank

Since the Independent Risk Assessment (IRA) defines and analyzes only the bounding intentional and vessel collision scenarios, the intentional scenario with the largest thermal radiation and flammable vapor dispersion results and the vessel collision scenario will be the focus of the Port Ambrose results. As detailed in Section 7 and presented below:

- Scenario 2 (Intentional attack leading to a 12 m^2 breach in two (2) LNGRV tanks) is the bounding intentional scenario for vapor cloud dispersion and thermal radiation at the DWP.
- Scenario 6 (vessel collision/allision with the LNGRV leading to a 23.1 m^2 breach) is the bounding accidental scenario for vapor cloud dispersion and thermal radiation at the DWP.

Scenarios 3 – 5 are additional intentional scenarios provided by Sandia for this DWP project. While the consequences were determined as part of the Phase I risk assessment, the hazard zones will be reviewed in detailed as part of the Phase II risk assessment. Therefore, the overlays for these three scenarios are not provided as results in Phase I since the location is not fixed. The Phase II risk assessment will used the hazards zones, as compared to the threat (to the port) and the vulnerabilities (based on the security measures for the project), to determine the risk for these scenarios and the need for additional security countermeasures.

8.1.1 Thermal Radiation Hazard Distances from Pool Fire

Thermal radiation hazard distances from a pool fire were estimated to two different heat flux levels:

- 37.5 kW/m^2: Damage to process equipment and storage tanks for unprotected exposures based on an average 10-minute exposure duration, as well immediate fatalities
- 5 kW/m^2: Permissible level for emergency operations lasting several minutes with appropriate clothing based on an average 10-minute exposed duration and onset of second degree burns based on an average 40-second exposed duration

Table 8-1 details the pool fire consequence results for the intentional (Scenario 1-2) and vessel collision (Scenario 6). This table details the number of tanks breached, release quantity (from the tank(s) breached), and distances to the 37.5kW/m^2 and 5kW/m^2 thermal radiation endpoints..

Table 8-1: Distances to Selected Thermal Radiation Hazard Levels

(Distances measured from the center of the pool)

Result	Scenario 1 (Intentional)	Scenario 2 (Intentional)	Scenario 6 (Collision)
Breach Size, m^2	16	12	23.1
Number of Tanks	1	2	1
Total Capacity of Impacted Tank(s), m^3	41,429	82,857	41,429
Release Quantity, m^3	29,000	58,000	29,000
Pool Fire Maximum Distance to Endpoint (meters)			
Pool Diameter, m	579	709	696
Thermal Radiation Endpoint > 37.5kW/m^2	970	**1,110**	1,090
Thermal Radiation Endpoint > 5 kW/m^2	2,270	**2,640**	2,600

The results and conclusions for this risk analysis have considered the most conservative thermal radiation distances. These results have been highlighted in bold-face type in Table 8-1. As shown, Scenario 2 is the bounding case for the intentional and accidental scenarios.

Sandia describes “zones” of risk to consider when evaluating risk reduction strategies for intentional and vessel collision spills of LNG:

- Zone 1: From ship to 37.5 kw/m2 – in this area, the risk and consequences of a large LNG spill could be significant and severe negative impacts; severe damage to structural including steel structures.
- Zone 2: From 37.5 kw/m2 to 5 kw/m2 area – the consequences of a large spill are of a varying damage; options for structural and personnel protection required or negatively impacted.
- Zone 3: Less than 5 kw/m2 – only minor impact on personnel if they move away from the fire.

8.1.2 Flammable Vapor Cloud Dispersion

The vapor cloud dispersion hazard distance was reported as the maximum downwind distance to the Lower Flammability Limit (LFL).

The flammable vapor cloud dispersion simulations were performed using FLACS. The distances to LFL predicted by FLACS for the intentional and accidental release scenarios are detailed in Table 8-2. All distances are measured from the center of the LNG pool.

Table 8-2: Distance to LFL

(Distance measured from the center of the pool)

Result	Scenario 1 (Intentional)	Scenario 2 (Intentional)	Scenario 6 (Collision)
Breach Size, m^2	16	12	23.1
Number of Tanks	1	2	1
Total Capacity of Impacted Tank(s), m^3	41,429	82,857	41,429
Release Quantity, m^3	29,000	58,000	29,000
Flammable Vapor Cloud Dispersion (No Ignition)			
Maximum Pool Diameter (m)	533	556	541
Distance to LFL, m	2,800	**3,550**	2,750

The major hazard of this consequence is the ignition and combustion of the flammable gas within the cloud--called a flash fire. A flash fire can result in potential impacts to the public and property. Due to the speed of the flame (as it propagates from the ignition source through the flammable range of the cloud), the impacts will be highly dependent on an individual's location (indoors vs. outdoors) and on the construction of the property exposed to the fire.

Thermal radiation effects from the vapor cloud fire can extend outside the flammable portion of the cloud and could result in a larger hazard distance as compared to the distance to LFL. But, due to the transient nature of this fire, the exposure duration from a flash fire is much shorter than exposure duration of a pool fire and is thus much shorter than the basis for the thermal radiation endpoints presented in Section 8.1.1. Assuming the flame acceleration of the flash fire is not impacted significantly by obstacles (consistent with the open nature of the DWP locations), the expected flame speed through the cloud could range from 8-17 m/s.[57] At these flame speeds, the exposure duration would not be significant, thus requiring a much higher thermal radiation exposure to result in comparable impacts to those listed in Section 8.1.1. Due to the uncertainty in the thermal radiation effects outside the flammable range of the vapor cloud, no additional thermal radiation has been considered and the hazard distances reported are limited to the distance to LFL.

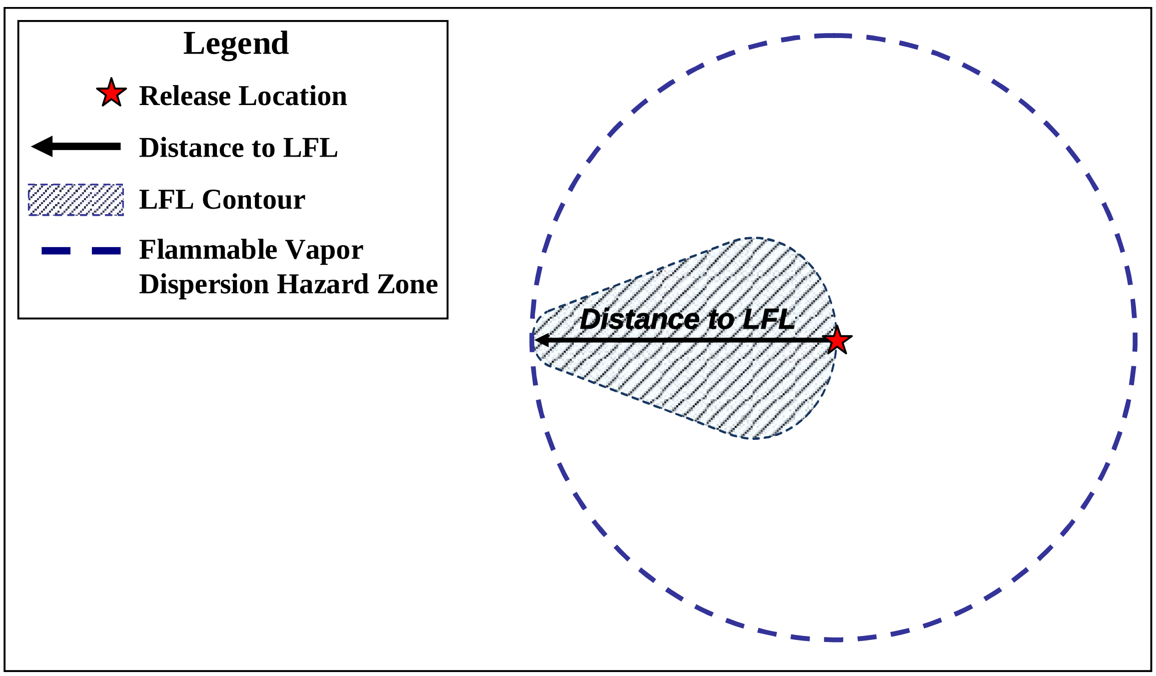
For both the thermal radiation and flammable vapor dispersion consequence results, the hazard zones are presented in Section 8.3 as overlays at the DWP buoy locations. As compared to the pool fire consequence, where the thermal radiation hazard extends radially from the pool fire center (assumed to be the ship), and the flammable vapor dispersion hazard will extend as a cloud dispersing in the downwind direction. Since the flammable vapor dispersion hazard zone is dependent on the wind direction at the time of release, the flammable vapor dispersion hazard zone overlays for the IRA are depicted as a circular area, with a radius equal to the maximum distance to the LFL, and centered at the spill location (assumed to be the ship). This representation of the flammable vapor hazard is independent of wind direction, illustrating the hazard from all wind directions.

[57] P.K. Raj, et al., *Experiments involving pool and vapor fires from spills of liquefied natural gas on water*, Arthur D. Little, ADA 077073, June 1979.

As shown in Figure 8-1, the actual hazard of the flammable vapor dispersion consequence is only in the downwind direction, and only within the LFL contour. The contour is the outer shape of the cloud out to a concentration equal to the LFL. As a result of the large release quantities and large pool sizes associated with the bounding cases of the IRA, the LFL contour (5% methane concentration level) does not result in a dispersion profile with a classical cigar/elliptical shape. This cloud shape is also illustrated in the CFD results in Section 7, showing that near the origin of the spill the shape of the cloud is dominated by heavy gas effects and, farther downwind the cloud transitions to the more classical dispersion profile, tapering off at the maximum LFL distance. It should be noted that the illustration in Figure 8-1 has not been drawn to scale, and only illustrates the portion of the cloud with a concentration greater than or equal to the LFL. The illustration is presented here to inform the public that while the hazard zone is overlaid as a circle in Figure 8-4 and Figure F (in the Executive Summary), not all portions within the circular hazard zone are expected to be impacted from a release.

Figure 8-1: Example Flammable Vapor Dispersion Hazard Zone

(Illustrated with predominate wind direction from the east)



8.2 Ship Collision Frequency Results

The total frequency of a collision with an LNGRV at the DWP was calculated for two vessel types: 1) vessels in the established Ambrose to Nantucket lane and Hudson Canyon to Ambrose lane; and, 2) vessels randomly passing the DWP location. This calculation utilized vessel traffic from the AIS dataset for this project and only included those vessels with the potential to breach the inner hull of the LNGRV in a collision.

Due to the distance between the DWP and the vessels in the two adjacent traffic lanes, the likelihood of a powered and drifting collision from vessels in these defined routes and the LNGRV was unlikely. In addition to vessels in the defined fairway, vessels of sufficient displacement and speed were identified that passed near the DWP. Using the collision frequency calculation for randomly distributed vessels, the likelihood for these vessels colliding with the DWP was calculated. However, given the small number of random vessels and the size of the LNGRV the likelihood is also unlikely.

The collision frequency for the proposed DWP considering both vessels in the two adjacent traffic lanes and randomly distributed around the DWP is shown in Table 8-3.

Table 8-3: Frequency of Vessel Collisions for Proposed DWP

TRAFFIC LOCATION	ANNUAL FREQUENCY OF COLLISION (COLLISION PER YEAR)	COLLISION ESTIMATED PERIOD (YEARS PER COLLISION)
Ambrose to Nantucket Lane	2.13×10^{-5}	1 collision every 47,000 years
Hudson Canyon to Ambrose Lane	7.98×10^{-9}	1 collision every 125,000 years
Randomly Distributed	1.67×10^{-8}	1 collision every 60,000 years
TOTAL	$\mathbf{2.13 \times 10^{-5}}$	**1 collision every 47,000 years**

8.3 Conclusions

The conclusions of the IRA are presented as the analysis of the following proposed Project combinations as specified by USCG:

- Alternative A: Baseline, no DWP built
- Alternative B: Port Ambrose built

If the Port Ambrose project is built (Alternative B), there is only one area where the potential hazard zones for thermal radiation and flammable vapor dispersion need to be considered and that is directly around the DWP buoys as illustrated by the consequence modeling zones. No results are shown for Alternative A (Baseline, no DWP built) as this alternative is simply the “as-is” case for this area and the proposed DWP location.

The conclusions of this risk assessment are presented as the hazard zones for thermal radiation hazard and vapor cloud dispersion for the worst case bounding scenarios evaluated. The hazard zones have been presented as graphical overlays on the nautical chart for the proposed DWP project location. The results of the Port Ambrose IRA are presented without passing judgment on the merits of the applicant’s proposed DWP. While the IRA evaluated the potential impacts to the public or surrounding infrastructure, it did not attempt to predict the number of estimated fatalities or injuries from these events. Also, the IRA was completed without considering any mitigation measures that could be implemented to reduce the risk of accidental or intentional release of LNG from this proposed project.

For reference, two thermal radiation endpoint levels are evaluated and presented and are defined as:

- 37.5 kW/m^2: Damage to process equipment and storage tanks for unprotected exposures based on an average 10-minute exposure duration, as well immediate fatalities
- 5 kW/m^2: Permissible level for emergency operations lasting several minutes with appropriate clothing based on an average 10-minute exposed duration and onset of second degree burns based on an average 40-second exposed duration

The pool fire calculations report the distance to each of these two thermal radiation hazard zones estimated, respectively, from the LNGRV release location, and measured from the center of the pool fire. The vapor cloud dispersion hazard distance was determined as the maximum downwind distance to the Lower Flammability Limit (LFL).

The proposed Port Ambrose falls within the proposed area of interest for the wind energy project(s) proposed for offshore New York as described in the Bureau of Ocean Energy Management's Call for Information of May 28, 2014 (79 FR 30645). The risk assessment will take this proposal into account; however, because of the lack of wind energy specific project details, this report is necessarily constrained in its ability to provide an analysis of the navigational safety risks that operation of the deepwater port may have on a future wind farm siting and operation. While it would be inappropriate for this report to purport to establish specific setbacks between the deepwater port, vessels operating in the area, and the wind farm, this report does provide information on LNG spill consequences which will help inform any future offshore wind energy project proponent on future siting of wind turbines.

To the extent practicable, in the absence of a detailed wind farm application, the Phase II portion of the IRA will examine navigational safety concerns and consider applicable measures that may serve to mitigate potential risks of both facilities operating in the same geographic area

8.3.1 Port Ambrose DWP Area Consequence Results

This section presents the thermal radiation and flammable vapor dispersion hazard zones at the Port Ambrose DWP buoy locations. As discussed in this report, the project consists of two buoy locations (Buoy #1 and Buoy #2) where an LNGRV can be moored, regasify LNG, and distribute natural gas into the subsea pipeline to shore. A summary table detailing the consequence modeling results for the bounding release scenarios evaluated in the risk assessment is presented in Table 8-4.

The pool fire and thermal radiation results for Scenarios 2 and 6 are shown in Figure 8-2 and Figure 8-3, respectively. These scenarios represent the bounding thermal radiation hazards for the intentional and vessel collision scenarios. In Figures 8-2 and 8-3, the consequence is shown as the radial distance overlaid and centered at the buoy locations to the two thermal radiation hazard endpoints. The hazard zones of Scenario 2, modeled as an intentional 12 m^2 breach in two of the LNG compartments of an LNGRV, and the thermal radiation zones for Scenarios 6 (vessel collision). Scenario 2 resulted in larger hazard zones. As shown in Table 8-4, the thermal radiation distances for Scenario 2 extend 1,110 meters to 37.5 kW/m^2 and 2,640 meters to 5 kW/m^2. For Scenario 6, the distances are 1,090 meters to 37.5 kW/m^2 and 2,600 meters to 5 kW/m^2. These results and graphical overlays illustrate that a pool fire at either Buoy #1 or Buoy #2 would not impact the other buoy location from a sustained fire at the 37.5 kW/m^2 and 5 kW/ m2 radiation levels. Additionally, as shown, the safety fairway is not impacted at these radiation levels.

Table 8-4: Consequence Modeling Summary Results

(Distances measured from the center of the pool)

Result	Scenario 1 (Intentional)	Scenario 2 (Intentional)	Scenario 6 (Collision)
Breach Size, m^2	16	12	23.1
Number of Tanks	1	2	1
Total Capacity of Impacted Tank(s), m^3	41,429	82,857	41,429
Release Quantity, m^3	29,000	58,000	29,000
Pool Fire Maximum Distance to Endpoint (meters)			
Pool Diameter, m	579	709	696
Thermal Radiation Endpoint > 37.5kW/m^2	970	1,110	1,090
Thermal Radiation Endpoint > 5 kW/m^2	2,270	2,640	2,600
Flammable Vapor Cloud Dispersion (No Ignition)			
Maximum Pool diameter (m)	533	556	541
Distance to LFL, m	2,800	3,550	2,750

Figure 8-4 compares the flammable vapor dispersion results for Scenarios 2 and 6, represented as the distance to the LFL overlaid at the DWP buoy locations. As compared to the pool fire consequence, where the thermal radiation hazard extends radially from the pool fire center, the flammable vapor dispersion hazard will extend as a cloud dispersing in the downwind direction. The flammable vapor dispersion hazard (distance to LFL) is illustrated as a circle, since the cloud could disperse in any of 360 degrees, depending on the wind direction at the time of release, as illustrated in Figure 8-1. This dispersion in the downwind direction is also illustrated as a plume from the predominant wind direction (from the south).

As illustrated in Figure 8-4, the intentional scenario (Scenario 2) results in the greatest distance to LFL, and an intentional incident at either buoy could potentially impact the other buoy location (see Figure 3-5). However, given a dispersion duration of over 20 minutes to the other buoy location, the other LNGRV has an emergency buoy disconnect that can shutdown regasification and disconnect the LNGRV in 15 minutes.

In addition to impacting the other buoy, the dispersion distance to LFL from Scenario 2 (from Buoy #2) could also impact Ambrose to Nantucket lane, depending on the wind direction (see Figure 3-5) at the time of release. As discussed above, a similar dispersion time of over 20 minutes is predicted for the cloud to reach the shipping lane.

Figure 8-2: Port Ambrose DWP (Thermal Radiation Hazard Zones - Scenario 2)

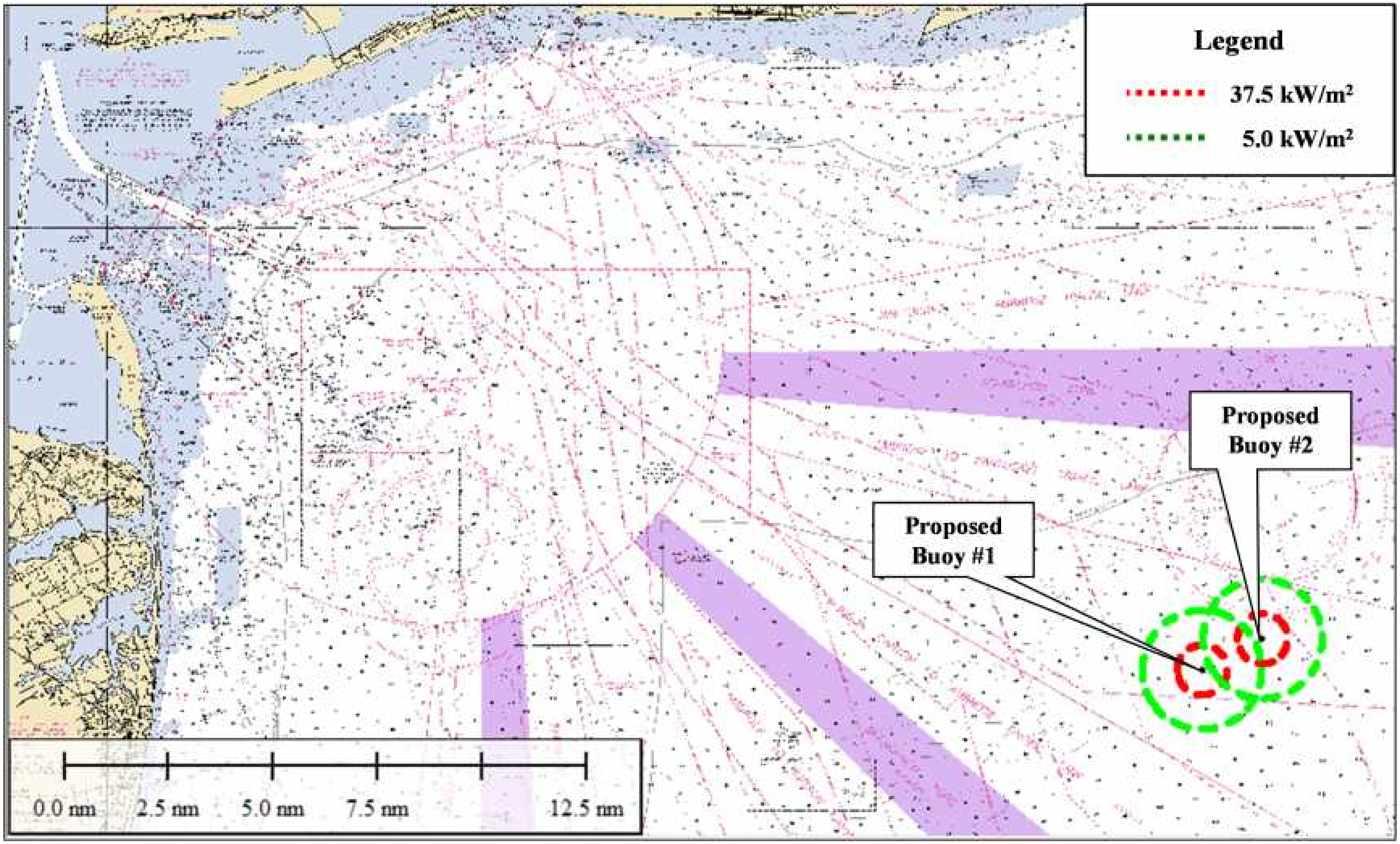


Figure 8-3: Port Ambrose DWP (Thermal Radiation Hazard Zones - Scenario 6)

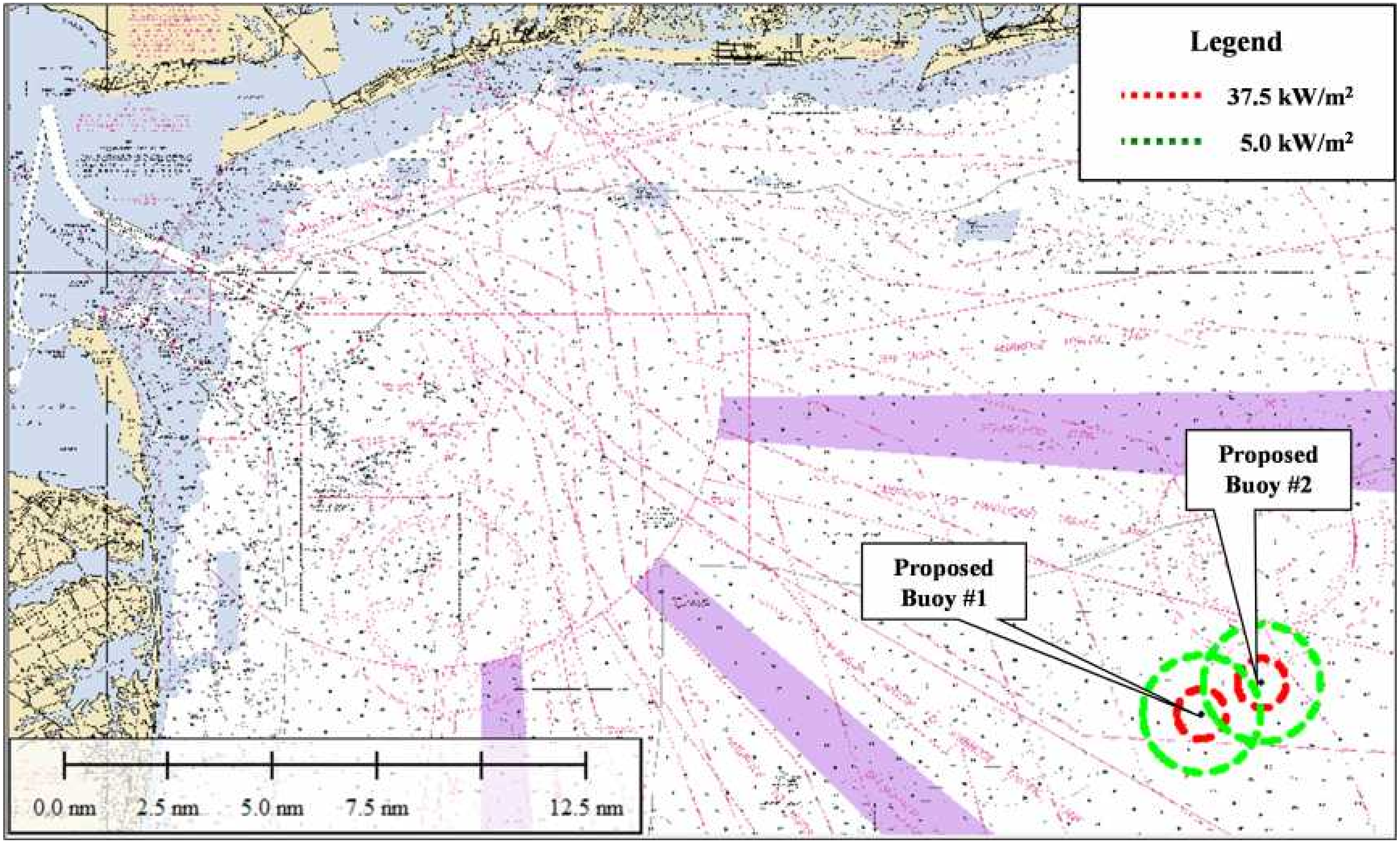
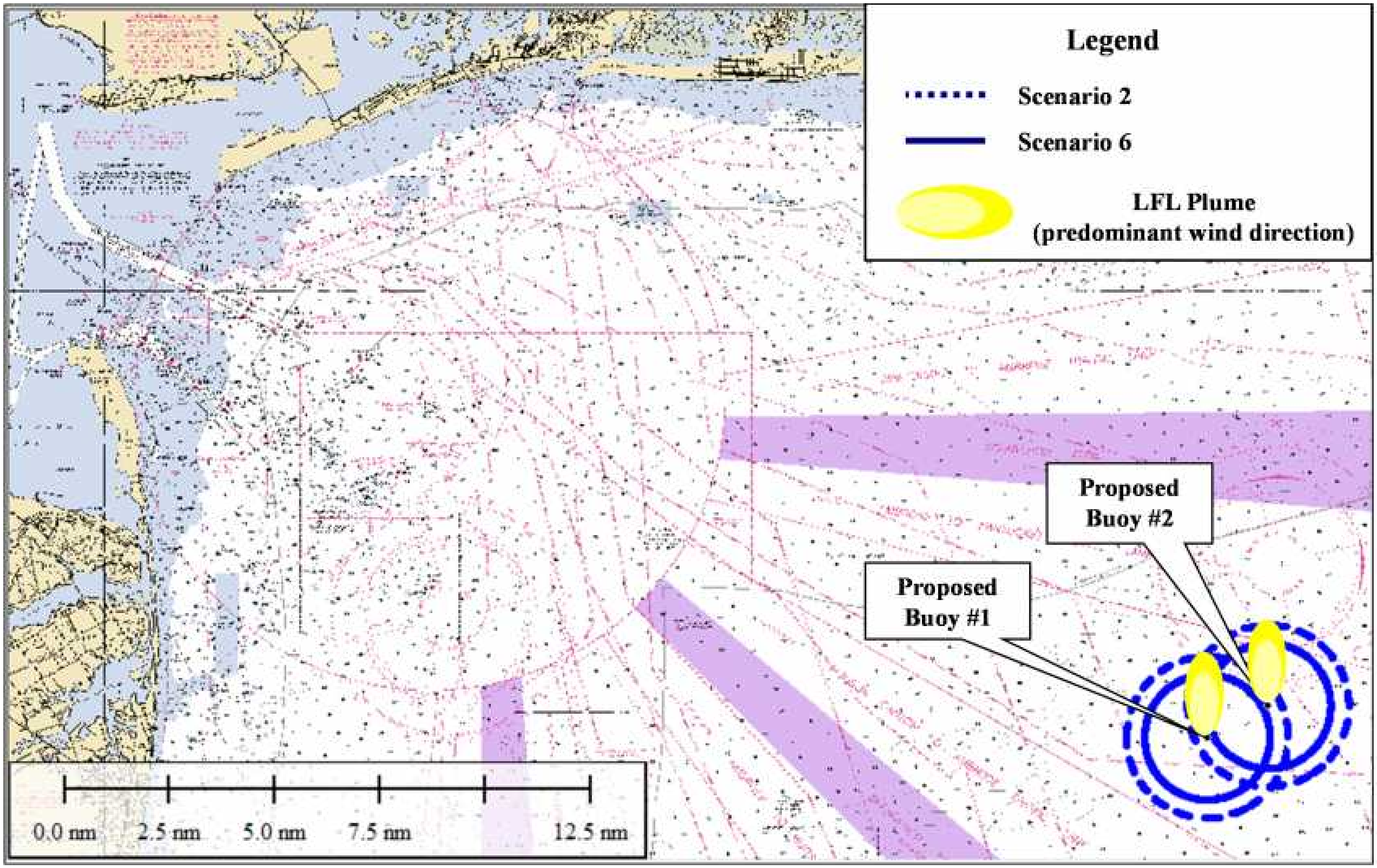


Figure 8-4: Port Ambrose DWP Vapor Cloud Dispersion - Distance to LFL



References

8.4 Standards:

- Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (Gas Carrier Code), 1983
- 1994/1996 Amendments to the IGC (replaced the Gas Carrier Code)
- DNV OS-F101, Det Norske Veritas, Submarine Pipeline Systems
- International Code for Ships Carrying Liquefied Gases in Bulk (International Gas Code [IGC]) 1993.
- International Convention for the Prevention of Collisions at Sea (COLREG)
- International Convention for the Safety of Life at Sea (SOLAS) (1974/1981)
- International Convention on Standards of Training, Certification and Watchkeeping (STCW) for Seafarers, 1978
- International Management Code for the Safe Operation of Ships and for Pollution Prevention (International Safety Management Code [ISM Code], adopted by IMO Resolution A.741 (18) in 1994
- International Safety Management Code

8.5 Regulatory References:

- Deepwater Port Act of 1974 as amended by the Maritime Transportation Security Act of 2002; (33 United States Code 1501)
- LNG Facilities: Federal Safety Standards (49 CFR 193)
- Maritime Transportation Security Act of 2002 (MTSA)
- Natural Gas Pipeline Safety Act of 1968, as amended, (NGPSA) and Hazardous Liquid Pipeline Safety Act of 1979 as amended (HLPSA) both recodified as 49 U.S.C. Chapter 601
- National Environmental Policy Act (NEPA)
- Notice of Availability of Detailed Computations for the Consequence Assessment Methods for Incidents Involving Releases from Liquefied Natural Gas Carriers, Federal Energy Regulatory Commission, Docket No. A04-6-000, June 29, 2004.
- Title 33 USC 1501 (Deepwater Port Act of 1974 as amended by the Maritime Transportation Security Act of 2002)
- Title 49 CFR 190-199 (Pipeline Safety Programs)
- Title 49 CFR 193.2057 (Liquefied Natural Gas Facilities: Federal Safety Standards -- Thermal Radiation Protection)
- Title 49 CFR 193.2059 (Liquefied Natural Gas Facilities: Federal Safety Standards -- Flammable Vapor-Gas Dispersion Protection)

Appendix O

LNG Facility and Carrier Safety Record

LNG Land-Based Facility Safety Record

A review of available information is limited to land-based LNG facilities and indicates there have been only seven documented incidents with one or more (worker and/or public) fatalities associated directly with operations at land-based LNG facilities; (1) Skikda, Algeria, Jnauary 2004; (2) Bontang, Indonesia, (3) Maryland, United States, 1979; (4) Arzew, Algeria, 1977; (5) New York, United States, 1973; (6) Raunheim, Germany, 1966; and (7) Ohio, United States, 1944. Two of the seven incidents were related to construction or maintenance activities at the LNG facilities and not directly to LNG operations (CH-IV International 2006). These incidents include:

- **Skikda, Algeria, January 2004**. Available reports suggest that a gas cloud of unknown origin found a source of ignition in a boiler resulting in a large fire. Twenty-seven individuals were killed in the incident. The preliminary investigation suggests more liberal use of gas detection instruments in LNG facilities as a preventative measure, especially in the vicinity of air intake devices (CEC 2004; Kornfield et al. 2004).
- **Bontang, Indonesia, 1983**. An overpressure explosion occurred due to a valve being inappropriately in the closed position during facility maintenance. Three individuals were killed. Industry analysts have classified this as a maintenance accident since no LNG was present in the system (CH-IV International 2006). Current standards and practices for management of valves in relief systems should prevent recurrence of such an incident.
- **Maryland, U.S., 1979**. An explosion occurred in an electrical substation at a LNG receiving terminal. One individual was killed. No gas detection system was installed in the substation because natural gas was never expected to enter. As a result of the incident, design code changes were made and applied industry-wide (CH-IV International 2006).
- **Arzew, Algeria, 1977**. Due to the rupture of a cast aluminum valve, LNG was released from an inground storage tank. One worker was killed. Industry standard practice now is to use stainless steel for fabrication of large valves (CH-IV International 2006).
- **Staten Island, New York, U.S., 1973**. A LNG tank was out-of-service for repairs. Mylar and foam liner materials ignited, leading to temperature rise and pressure surge. The pressure surge caused a roof collapse, killing 37 workers who were inside the tank. The investigation classified this as a construction accident, not a LNG accident (CH-IV International 2006). Compliance with OSHA requirements for confined space entry and hot work should prevent recurrence of such an incident.
- **Raunheim, Germany, 1966.** Accidental venting occurred while LNG was being passed through a vaporizer that used a liquid level controller to operate below its maximum capacity of 4000 kg. The resulting vapor cloud drifted towards a control room resulting in fire and explosion, killing one. It was determined that the liquid level failed and as a result around 500 kg of LNG was vented out of the vaporizer (ÅF Industry AB and SSPA Sweden AB 2011).
- **Cleveland, Ohio, U.S., 1944.** A LNG storage tank built with low-nickel content steel failed shortly after being placed into service, resulting in a leak and subsequent fire that killed 128 people. The investigation concluded that, had the tank been built to code, the accident would not have occurred (CH-IV International 2006).

LNG Carrier Safety Record

Year	LNG Carrier	Incident
2012	*LNG Aries*	On June 20, 2012 off the coast of Oman, pirates attacked the Aries with rocket propelled grenades and small arms fire. The pirates moved to within 50 meters and fired shots, of which three rounds hit the tanker and damaged it. No one was injured during the attack and the LNGC evaded hijack. The LNGC was classified as safe and continued its scheduled voyage from Port Said to Suez.
2006	*Golar Freeze*	The LNGC moved away from its docking berth during unloading on March 14, 2006 in Savannah, Georgia. The powered emergency release couplings on the unloading arms activated as designed and transfer operations were shut down.
2004	*Tenaga Lima*	The *Tenaga Lima* grounded on rocks while proceeding to open sea east of Mopko, South Korea due to strong current in November 2004. The shell plating was torn open and fractured over an approximate area of 20 feet by 80 feet, and internal breaches allowed water to enter the insulation space between the primary and secondary membranes. The ship was refloated, repaired and returned to service.
2002	*Norman Lady*	The USS Oklahoma City nuclear submarine struck the *Norman Lady* while rising to periscope depth near the Strait of Gibraltar in November 2002. The 87,000 m^3 LNG tanker, which had just unloaded its cargo at Barcelona, Spain, sustained only minor damage to the outer layer of its double hull with minor leakage of seawater into the double bottom ballast tanks. No damage to the inner hull or the cargo system and tanks occurred.
2002	*Mostefa Ben Boulaid*	LNG spill onto its deck during loading operations in Algeria in 2002. The spill, which is believed to have been caused by a check valve leak, caused brittle fracturing of the steelwork. The ship's emergency shutdown system, water spray system and response of the crew resulted in a minimum of serious damage. Current ship design includes protective cryogenic metal protective plates under the transfer area, usually with a water flow, which protects the ship’s deck. The ship was required to discharge its cargo, after which it proceeded to dock for repair.
2001	*Khannur*	A cargo tank overfilled into the ship’s vapor handling system on September 10, 2001 during unloading at Everett, Massachusetts as a result of a malfunctioning valve. Approximately 100 gallons of LNG were vented and sprayed onto the protective decking over the cargo tank dome, resulting in several cracks. After re inspection by the USCG, the *Khannur* was allowed to discharge its LNG cargo.
2001	*Methane Polar*	The ship collided with the bulk cargo ship Eastwind about 34 miles off the Algerian Coast. Although the *Methane Polar* sustained some damage, it remained in a stable condition and was later repaired. The Maritime and Port Authority stated that there were no reports of any cargo release or pollution from the collision.
1989	*Tellier*	The *Tellier* was blown from its docking berth at Skikda, Algeria in February 1989 during severe winds causing damage to the loading arms and the ship and shore piping. The cargo loading had been secured just before the wind struck, but the loading arms had not been drained. Consequently, the LNG remaining in the loading arms spilled onto the deck causing fracture of some plating. As a result of this incident, LNG loading arms are now fitted with ship position monitoring devices, including transfer shutdown and emergency “dry break” couplings for disconnection of the loading arms.
1985	*Isabella*	LNG spilled onto its deck due to a cargo tank overflow in June 1985, causing severe cracking of the steelwork. The spill had been attributed to a cargo valve failure during discharging of cargo.
1980	*LNG Taurus*	The *LNG Taurus* grounded in December 1980 near the entrance to Taboata Harbor, Japan. The grounding resulted in extensive bottom damage, but the cargo tanks were not affected. The ship was refloated and the cargo unloaded.
1980	*LNG Libra*	The propeller shaft fractured while the ship was en route to Japan with a full cargo in October 1980. The ship was taken under tow, and the cargo was safely transferred to another LNG ship and delivered to its destination.

Year	LNG Carrier	Incident
1979	*El Paso Paul Kayser*	The ship grounded on a rock pinnacle in June 1979 in the Straits of Gibraltar during a loaded voyage from Algeria to the United States. Extensive bottom damage to the ballast tanks resulted; however, the cargo tanks were not damaged, and no cargo was released. The complete cargo of LNG was subsequently transferred to another LNG ship and delivered to its U.S. destination. The *El Paso Paul Kayser* proceeded to a shipyard under its own power with temporary repairs. LNG carriers are presently equipped with sophisticated navigation systems, including global positioning systems, which provides the ship's captain with the ship's exact position.
1979	*Pollenger*	A LNG spill onto the steel cover of cargo tank number one occurred while unloading at Everett, Massachusetts in April 1979. The spill caused cracking of the steel plate.